R Series, Vol. VII, Nos. 1-2 December 1949

PALESTINE JOURNAL OF BOTANY

Rehovot Series

(formerly the Palestine Journal of Botany and Horticultural Science)

EDITED BY

H. R. OPPENHEIMER and I. REICHERT

of the Agricultural Research Station, Rehovot, Israel

EDITORIAL SECRETARY:

J. PALTI

REHOVOT, ISRAEL

PALESTINE JOURNAL OF BOTANY

appears in two series

THE REHOVOT SERIES (R)

is edited by H. R. OPPENHEIMER and I. REICHERT, of the Agricultural Research Station, Rehovot, Israel. Each volume of this series is scheduled to comprise two issues per year, totalling 200—300 pages.

THE JERUSALEM SERIES (J)

is edited by the Staff of the Department of Botany of the Hebrew University, Jerusalem. Each volume of this series is scheduled to comprise four issues per year, totalling 300—400 pages.

Subscriptions are payable in advance by crossed cheque or postal order
The subscription price is

24 s. (£1. 4.—) per volume, for JERUSALEM SERIES
18 s. (£0. 18—) per volume, for REHOVOT SERIES

Subscriptions and correspondence concerning editorial or business matters should be addressed
for the JERUSALEM SERIES: Palestine Journal of Botany, P.O.B. 620, Jerusalem Israel.
for the REHOVOT SERIES: Palestine Journal of Botany, P.O.B. 15, Rehovot, Israel.

Subscriptions or correspondence for both series of the Palestine Journal of Botany may be sent to either of the above addresses.

Back volumes of REHOVOT SERIES are obtainable at 18 s. (£ 0.18.—) as far as still available.

M. Shoham's Press, Tel-Aviv, Tel. 2239

PALESTINE
JOURNAL OF BOTANY

Rehovot Series

(formerly the Palestine Journal of Botany and Horticultural Science)

EDITED BY

H. R. OPPENHEIMER and I. REICHERT

of the Agricultural Research Station, Rehovot, Israel

EDITORIAL SECRETARY :

J. PALTI

Volume VII

(1 9 4 9)

REHOVOT, ISRAEL

CORRIGENDA

(1) *In Boyko, Climax vegetation of the Negev*:

p. 21 last line instead of " in No 10 of the references " read
" in the reference quoted in the footnote on p. 17 "

p. 22 lins 17 and 18 have to be inserted after line 21
(i. e. after ... described in Table II.)

Note on pp. 32, 33

The planned excavation has in the meanwhile been carried out by the author and has strengthened the conclusions reached previously. The many stems and twigs of Haloxylon persicum protruding from high dunes are generally only parts of one single giant individual. The measurement of 1.60 m. diameter, however, was based on a misinterpretation: the excavation proved this specific stump to consist of three separate units which were encrusted by sand and stuck firmly together in a circular form.

The investigation showed further that besides the living twigs of Haloxylon, which protrude the dunes there, also occurs Tamarix articulata, itself new for the Araba.

(2) *In Boyko Climatic extrames*:

p. 49 and 50 The text of textfigures 2 and 3 have to be interchanged.

(3) *Damast properties of apple fornt*:

Page 105, table I, column 2 second line, instead of "5.17 + 0.009$_{,,}$, read
"1.17 + 0.009$_{,,}$.

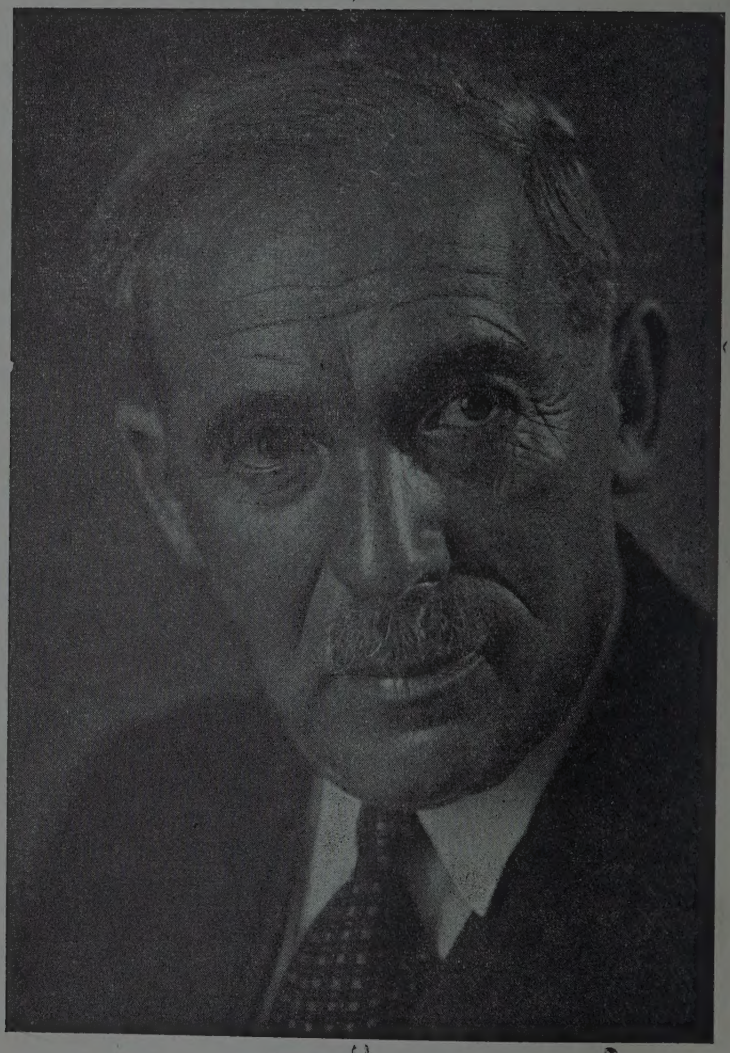
THIS SEVENTH VOLUME OF THE PALESTINE JOURNAL OF BOTANY, REHOVOT SERIES, IS DEDICATED TO THE DIRECTOR OF THE AGRICULTURAL RESEARCH STATION

PROFESSOR

I. ELAZARI-VOLCANI

THE PIONEER OF PLANNED JEWISH COLONISATION,

ON THE OCCASION OF HIS 70th BIRTHDAY.



IZHAK ELAZARI-VOLCANI

The national, scientific and agricultural authorities of Israel have recently celebrated the seventieth birthday of Professor Izhak Elazari-Volcani, Director of the Agricultural Research Station of the Jewish Agency and until recently, Dean of the School of Agriculture of the Hebrew University.

When Volcani came to Palestine 42 years ago, the agriculture of this country was in the throes of an acute economic crisis. The first sponsor of Jewish Colonisation in Palestine, Baron Edmond de Rothschild, had attempted to apply to this country the colonising methods practised by the French in North Africa. There a measure of success had been achieved by these methods, backed by the power of government and the agricultural experience of the French settlers. Here the first modern Jewish settlers in the last decades of the 18th century lacked both these essentials, and the scheme was doomed to failure.

It was at this juncture that Volcani, then known as the agronomist I. Wilkansky, made his first fundamental contribution to the cause of our national regeneration. A pupil of Sering and Mitscherlich, he applied the principles of modern science to advance Jewish agriculture from its oriental primitivity. The conceptions guiding him, equally sound from a national and an economic point of view, were (1) that Jewish settlement must be based on the settlers' work and not on hired labour, and (2) that individual farm units should strive to be selfsufficient. Under Volcani's direction the basic data required to plan colonisation along such lines were established step by step first at the Experimental Farm at Ben Shemen (founded by him in 1909) and then at the Agricultural Research Station at Rehovot (founded by him in 1921). This research has enabled our farmers to raise their anual output, in the course of a few decades from 40—60 to 150—200 kg. wheat per dunum, from 70—80 to 150—200 eggs pen hen, and from 700 to 4000 litres milk per cow.

The body of these investigations has been collected in about 300 publications of the institutions headed by Volcani. His own publications, written with verve and skill, have educated two generations and are classics of the economic foundation to the return of our people to the soil. Best known of his writings are his books "Baderech" (On the way) and "Midot" (Measures) which still serve as guides for planning our agricultural colonisation work. Outstanding, and of fundamental value for the agricultural revival of this as well as the surrounding arid countries, are his monographs (published also in English) on the

Fallah's farm, on the transition from primitive to intensive agriculture, on communal settlements, on planned mixed farming, and on various other subjects. These studies have earned the praise of eminent scientists such as Elwood Mead, the famous scholar and Reclamation Commissioner, in the U.S. and Sir John Russell of Rothamstead and have attracted much attention by leading colonisation experts such as Sir Walter Elliott and Sir Frank Stockdale of the British Ministry of Agriculture and the Colonial Office.

At the conference called in Cairo in 1944 by the Middle East Supply Centre Volcani gave the representatives of all neighbouring countries a review of he achievements of agricultural science in Palestine. More recently, in a comprehensive lecture in the Weizmann Institute of Science (Trends in modern science, 1949) he has traced the lines on which the backward agriculture of the Middle East could be made to develop on the basis of these achievements. He has thus had the satisfaction of showing how his scientific conceptions, originally evolved for the benefit of our small country, might help to model the entire structure of agriculture in this part of Asia.

The Editors

CONTENTS

THE TYPES OF SYMBIOTIC LINKAGE AND THEIR SIGNIFICANCE FOR THE FORMATION OF HIGHLY ORGANIZED FORMS, FUNCTIONS AND LIFE-SPHERES IN THE PHYLOGENETIC PROCESS OF DEVELOPMENT*)

By RICHARD FALCK, Haifa

INTRODUCTORY SURVEY

We distinguish c y t o s y m b i o s i s from s o m a t o - s y m b i o s i s as follows:

A. Cytosymbiosis comprises *elementary intracellular* linkage of two kinds of chromosomes or two kinds of nuclei within a single cell. Such linkage occurs at certain points of its ontogenetic development and persists in the perfect stages of each cell.

B. Somatosymbiosis comprises

(a) *endosmatic cellular* unions within a single individual for joint body formation;

*) Published simultaneously in the series of monographs issued by the Research Council of Israel.

(b) *exosomatic* relations of independent individuals that remain separated bodily but are linked to common function in a joint life-sphere.

Among the cytosymbioses of type A, i.e. those with elementary intracellular linkage, we distinguish:

(1) *Endocaryontic synchromatobiosis* (synchromosomy) characterized by diplo-nuclei (with double the regular number of chromosomes). This arises in sexual organs and may occur in vascular cryptogams, and in the realm of higher animals endowed with a sexual linkage character.

(2) *Intracellular syncaryobiosis* (syncaryon) characterized by the syncaryon. The latter, in the higher fungi, forms automatically without sexual organs through dynamic nuclear differentiation. From the caryological viewpoint this type of symbiosis represents a special group of organisms with a linkage character we propose to term dynamo-active.

(3) *Perfect synspecies symbiosis* characterized by cell linkage of two individuals belonging to distinct classes, to form a new type of organism that represents a new species, genus and class (*Lichenes*).

(4) *Imperfect parasitoid symbiosis,* also exhibiting cell linkage of two individuals of distinct species, genus and class, but without their bodily union leading to the formation of new organisms. One of the two species is dominant, remains unchanged in form, function and life-sphere, and is usually called the host, the other species is weaker and is generally called the parasite. The host remaining unchanged, the parasite adapts itself to the host in all its organs, loses its independence, and forms new species which in all parasitic fungi have led to new conceptions of genus, family and class.

The somatosymbioses further comprise the exosomatic linkage of individuals, which we term

(5) *Exosomatic associate symbiosis* — the organisms concerned remain bodily separated, living associates; only individual organs may enter into endosomatic linkage and may undergo changes in form and function, e.g. in the formation of mycorrhizae. Apart from that, mutual relations of the associate organisms remain solely functional in character and are correspondingly adjusted to the life-sphere. Two to three associates belonging to different realms of organisms may participate in such symbiosis. Of these, only fungi have undergone fundamental changes in structure and function even in their independent organs (fruiting bodies) to form new species, genera and classes(e.g. in the *Vescocarpiomycetes*).

The somatosymbioses represent the lower grades of symbiosis, while the cytosymbioses represent the highest and most intimate developmental stages of symbiotic relationship.

A. CYTOSYMBIOSIS

1. *Intracellular syncaryobiosis (syncaryon) on dynamo-active foundation in the higher fungi (type A2)*

Even before their distinct morphological characters were recognized, we have been able to divide what was formerly known as the species *lachrymans* of the genus *Merulius* into the two new species *domesticus* and *silvester* on the basis of their constantly distinct physiological temperature values (5 a). Only the subsequent monographic study of *Merulius* rot has enabled us to confirm, according to their constantly distinct morphological characters, that the two species thus created were valid.

In the present study we have further come to distinguish between the two types of nuclei always uniting to form the syncaryon of *M. domesticus* according to their constantly different temperature values, the optimum, the maximum, and the supramaximal lethal temperature. We have also proved that application of temperatures exceeding the supramaximal level of tolerance of the one, but not of both, of the nuclei may succeed in "selecting" the more temperature-resistant nucleus which can be kept viable indefinitely in its cell tissue, can be propagated through its *Oidium* spores, and can be maintained indefinitely in the select-nuclear monocaryontic state.

The monocaryontic condition of the mycelium of the temperature-susceptible complementary nucleus has also been demonstrated by means of isolated cultures of its spores.

Dealing with lysogamy and karyomerism, we have further shown (4) that half the spores of basidial fruits are provided with + nuclei, the other half with — nuclei. Their germination must therefore give rise to an equal number of + and — mycelia. This condition has been denoted as the heterothallic phase of the youngest primary mycelial system.

In its heterothallic condition the primary mycelium thus consists of two types which are separable for development independent of each other and have been known as "secondary fruiting forms". Mycelia raised from isolated spores persist as monocaryontic systems. But under natural conditions, where there is no such isolation, the two types of nuclei invest the mycelium they have jointly created, multiply therein and congregate in pairs. This condition persists for some time in the primary mycelium and represents the dyscaryontic system of this mycelium. Eventually the caryosyndetic act leads, almost simultaneously in all parts of the mycelium, to the linkage of the paired nuclei in the syncaryon. On completion of this act the primary gives rise to the secondary mycelium; this is invested only with syncarya and undergoes the structural and functional changes referred to above. It is then capable of forming syrrotia (4, p. 136) and basidial fruits and enters into the new life-sphere relationship characteristic of the higher fungi invested with syncarya.

But the application of supramaximal temperatures (above 26°C) can prevent the syncaryon act and effect the differentiation of the mycelia into *Oidia* even where the act of fusion has already taken place in the heterothallic system raised from basidiospores and where the two types of nuclei have entered into the dyscaryontic phase of their development. The resulting *Oidia* are partly of the + and partly of the — type. Though weakened and less vigorous than basidiospores raised from heterothallic systems, the *Oidia* may by fusion reach the dyscaryontic phase and thence progress to the syncaryontic secondary state of mycelium. The reason for these regressions is once again to be sought in the differential reaction of the types of nuclei to temperature threshold of the more susceptible form where the maximum temperature threshold of the more susceptible nucleus has been exceeded.

Lastly, we have been able to show also for the syncaryontic secondary phase of *M. domesticus* that application of supramaximal temperature may effect separation of its two component types of nuclei, remove the complementary nucleus more susceptible to temperature, and leave only the more resistant basic nucleus. Reduction is thus effected into a monocaryontic, primary mycelium which may be indefinitely propagated as such by means of *Oidia*. It is incapable of reverting to the dyscaryontic and the syncaryontic condition, maintains its primitive morphological and functional characters and is unable to subsist on wood or to disintegrate it.

The fundamentally distinct physiology of the two types of nuclei as regards their temperature values and their differential dynamic character (+ and —) leads to the conclusion that their inner structure may also be assumed to differ. We therefore consider the + and — forms as two physiologically distinct species not hitherto distinguishable by their morphological features. Though the species are distinct, they are undoubtedly closely related.

The fundamental differences in inner structure and function is particularly well brought out by the fact that syncaryontic linkage gives rise to a new organism basically different in form, function and life-sphere from the two oidial forms of the primary mycelium. The new organism not only belongs to another genus, family and class, but in its syncaryontic linkage also reaches the highest level of organisation encountered among fungi.

If the two types of nuclei were alike in their physiological differentiation and inner structure, their intimate syncaryontic linkage could not produce an organisation as basically different as the principal fruiting form is seen to be when compared with the secondary ones.

On these grounds we define the highly developed organism of the principal fruiting form, which results from linkage in syncaryon, as the product of intimate intracellular symbiosis of two types of nuclei possessing a close degree of relationship.

This contrasts with the B type of somatosymbiosis which usually concerns individuals and nuclei belonging to distant species, classes or even kingdoms, that nevertheless unite to form organisms new in structure and function.

Thus the realm of the higher fungi is characterized from a caryological point of view by possessing two closely related types of nuclei which are yet dynamically and physiologically distinct; though separate and independent of each other, these nuclei are yet symbiotically linked in each hyphal cell. Each individual nucleus is capable of forming an independent organism of a low order and to propagate thereby in secondary fruit forms. In their syncaryontic linkage they form a double species, the so-called principal fruit form belonging to the highest level of development, fundamentally differing in structure, function and life-sphere from the secondary fruit form with which it is, however, linked ontogenetically by a common course of development. With this double species we arrive at the new conception of "s y n c a r y o n t i c c o m p o s i t e s p e c i e s".

In the fungi phylogenetic development to this highest level of organisation is thus based on the cytosymbiosis of two closely related types of nuclei in syncaryon and composite species.

2. *Endocaryontic synchromatobiosis* (*synchromosomy*) *on a sexual basis in vascular cryptogams, higher plants and animals* (*type A*1).

By contrast with intracellular syncaryobiosis we define sexual endocaryontic linkage as the union of two sexually different kinds of chromosomes within the space of a s i n g l e nucleus.

These sexual chromosomes differ not by being derived from distinct species (as in syncaryobiosis), but by being derived from distinct individuals where the sexual organs are borne by two separate individuals. These chromosomes from identical species, paired as they also are in the nuclear space, are not endowed with dynamic forces of attraction and linkage. They are conducted to each other by special threads of the nuclear skeleton and are placed so close together that their linkage does not require the syndetic forces that are needed in chromosome linkage in the syncaryon. This fact distinguishes the sexual chromosome type of the organisms equipped with sexual organs from the dynamic type of attraction, effective over a distance, as found in the syncaryon chromosomes of higher fungi.

The sexual chromosomes can unite only in a single nucleus by the act of endocaryogamy. The cells they belong to thus always contain only a single nucleus, but this is a diplo-nucleus provided with a double chromosome complement.

We therefore consider sexually produced endocaryogamy to constitute likewise a cytosymbiosis of two types of chromosomes — a symbiosis of the most intimate nature where the smallest units supporting the whole organisation, the chromosomes belonging to

two separate individual, join forces to form the complete organism.

The sexual nuclei formed in the sexual organs contains only half the chromosome complement required for the formation of the diplo-nucleus and for the further development of the organism. They have therefore been termed appropriately "haplo-nuclei".

The "haplo-nuclei" further differ essentially from the dynamo-active "selected" nuclei of the various spore forms of the higher fungi by the fact that sexual cells possessing haplo-nuclei are incapable of developing into independent organisms. Even in cases of parthenogenetic development of the ovum, which is exceptional, the result is not a different, and lower organism, such as produced by each of the component nuclei of the syncaryon, whether isolated naturally or artificially. Artificial division of a diplo-nucleus into two haplo-nuclei has not been reported and is not to be expected.

We may distinguish two stages of cytosymbiontic nuclear union, viz. synchromatobiosis taking place within a single nucleus, and syncaryobiosis of two separate nuclei within a single cell. Synchromatobiosis characterizes organisms with sexual organs, sexual cell, and sexual differentiation of nuclei; the tissue cells are mononuclear; the nuclei are diplo-nuclei possessing a double chromosome complement. Syncaryobiosis characterizes the organisms without sexual organs or sexual cells with dynamic differentation of nuclei. Their tissue may possess one or two nuclei, and they may accordingly possess twofold form, functions and life-spheres. Those possessing two nuclei bear the syncaryon and are of a higher level of organisation. Those possessing a single nucleus or two nuclei not linked to one another represent different species of a lower level of organisation.

The nuclei of the syncaryon remain separated in space and are linked by two kinds of dynamic forces: they are paired by kinetic energy, while syndetic energy links them in the syncaryon and by this linkage facilitates the functional co-operation of their separate chromosomes. Linkage of the two nuclei ceases in the act of lysogamy, which terminates their higher phase of development, and they are then reduced by caryomerism to the isolated monocaryontic, lower phase.

It is thus quite evident that in the realm of the higher fungi intracellular cytosymbiosis of two nuclei belonging to distinct species — with the nuclei remaining separated in space — results in phylogenetic development to the highest level of organisation. The numerous classes, families, genera and species constituting the higher fungi obviously owe to this symbiosis their formation as well as their existence with all their life-sphere relationships including those of the most specialized kind.

B. SOMATOSYMBIOSIS

1. *Symbiosis of endosomatic cell tissues*

It is a remarkable fact that the higher fungi — presumably owing to their intracellular syncaryobiosis — have also acquired the capacity of entering into far-reaching symbiotic relationship with certain groups of organisms belonging to different kingdoms. Regular intracellular cytosymbiosis of chromosomes or nuclei with those of distant types of organisms have not so far been observed apart from certain hybridisations of quite irregular occurrence.

The class of the *Lichenes* represents a peculiar group in which the cells of higher fungi have entered into endosomatic linkage with the cells of certain aerial algae and this linkage constitutes new types of organisms constant in their form and function. As regards their life-sphere, the lichens are distinguished by their capacity to thrive in climates or habitats in which neither fungi nor algae can grow separately; their symbiosis alone opens up such habitats to both these groups of organisms.

The tissues of lichens may be separated neatly into fungus cells and algal cells, or their respective complexes, and either can be propagated in culture. Similarly, it has been possible to synthesize lichens from their component parts (1, 8, 11), much as they form in nature from fungal spores and algal cells or from aggregates of fungal and algal cells.

The lichens represent the perfect type of somatosymbiosis, but the two components are incapable of entering an intimate intracellular cytosymbiosis of chromosomes or nuclei. The shapes of cells and fruiting bodies of the two components likewise remain unchanged in spite of the fact that as lichens they constitute in their form, function and life-sphere new species, genera and classes of a distinct realm of plant life.

The symbiosis of lichens is thus solely endosomatic and much less intimate than the syncaryobiosis of the two secondary fruiting forms of higher fungi that produces the primary fruiting form. Nevertheless, the species and genera of the class *Lichenes* have retained their separate names long after their composition from known classes of algae and fungi was recognized and after their ontogenetic development from fungal and algal cells was discovered.

This is essentially due to the fact that the specific distinction between the two components of lichens have long been known, whereas such specific distinctions between two closely related secondary fruiting forms and their nuclei are being postulated for the first time in this study. As regards the fundamental difference between the secondary fruit forms and the primary one in the species, genus and class they belong to, this should be considered evident.

In advocating a fundamental distinction between these two types of fruiting forms even in their nomenclature, we may well base ourselves on the precedent of the lichens. But is should be borne in

mind that close ontogenetic relation has been demonstrated beyond a doubt to exist in many cases between the primary and secondary forms. This fact could be suitably appreciated by giving the two forms a common specific name, viz. that of the primary form, while applying distinct generic names to mark their fundamentally distinct character in form, function and life-sphere, and their belonging to widely different genera, family or classes.

A new significance, by an attempt to adapt them to newly established facts, is thus conveyed to the concepts of species and genus as relating to higher fungi which have proved to constitute synspecies of primary and secondary fruiting forms. The specific name denotes the ontogenetic relationship of a syncaryontic primary fruit form with two select-nuclear but independent, lower subspecies, the secondary fruiting forms, which form in their ontogenesis a double species (= synspecies). The distinct generic name denotes dissimilarity in form, function and life-sphere so that primary and secondary fruiting forms are placed into separate genera. Otherwise we would have to create two distinct sub-species to accomodate the conceptions of synspecies and haplo-species, and this would imply adoption of a ternary nomenclature.

2. *Perfect and imperfect symbiosis*

(a) *Perfect synspecies symbiosis*

In lichens the two components are equivalent and their symbiotic relationship is perfect in as much as b o t h are fundamentally concerned in the structural and functional changes. The newly formed species, genera and families of lichens do not retain the character of either simple fungi or free algae. In each individual lichen the two components complement one another in form, function and life-sphere to the effect that neither component alone could be recognized as a lichen or exist in the life-sphere of a lichen.

(b) *Imperfect parasitoid symbiosis*

Apart from their association with algae, fungi may enter into endosomatic linkage with members of all other families of plants; however, the partners in these linkages are not equivalent and the result is not the perfectly balanced relationship of form and function of the lichens.

The green plant in general retains its form and function as well as its life-sphere and remains dominant in the symbiotic relation. On the other hand, the fungus irrevocably loses its original form and function which it perfectly adapts to the life-sphere of the plant or of the plant organ it inhabits.

The green plant remains independent of the fungus in its nutrition and propagation — und thus in its entire existence — and its life follows the same course, irrespective of the presence or absence of the fungus. But the fungus is wholly dependent on the higher plant in its nutrition and propagation and has given up its free

and separate existence, adapting itself to the requirements of common development. Yet certain species, groups, families and classes of fungi have, even in this state of "bondage", progressed in their development (*Uredineae, Ustilagineae*) (5b).

This common existence of fungus and higher plant has usually been judged only by the adverse economic effect it produced. Cultivation of individual crops on a larger scale may favour excessive development of fungi on the crop plant, and this is bound to be reflected in losses of yield. The losses thus incurred have caused the studies of the biology of the fungi and their hosts to be directed essentially to the end of checking the development of the fungus and thus promote that of the crop plant.

i. *Is fungal invasion purely detrimental to the host* ?

The conception of the parasitic rôle played by the fungi on their hosts is based on the assumption that the host plant can only suffer by the fact that the fungus deprives it of nutrients, while it derives no advantage from fungal development. The various ways in which plants may be harmed have been studied in detail with regard to all major fungal diseases. But the plants have not so far been observed to benefit from fungal growth.

We owe Ernst Gæumann and his teacher Eduard Fischer (6) a complete study of this subject and a comprehensive survey of world literature up to 1929. In the fourth chapter of their "Biologie der pflanzenbewohnenden Pilze" these authors deal with all the various detrimental effects of the parasite on the host: (a) destructive effects and changes; (b) changes in host metabolism and chemical reactivity; (c) effect on growth and morphogenesis; (d) changes in adaptation to environment; (e) changes in periodicity. There is no mention of any beneficial effect of the fungi.

In fact, the question whether the host may derive any benefit from the fungus has no place in the accepted view, where the two types of organisms are considered to fight one another as a fitting part of the general conception of the "struggle for existence". In this view the fact that only certain species of hosts are liable to invasion by certain fungi is due to the lack of an adequate defensive capacity in these hosts. The fungi are assumed to be capable of forcing their entry into and spread through the hosts. This unilateral aggressive adaptation of parasitic fungi for the fight with certain host species is said to have resulted in the course of phylogenetic development in the perfection of suitable forms and functions; whereas the unchanged forms and functions of the host indicate that the latter has been unable to organize its defence adequately. Thus parasitic fungi are eventually to have thrived at the expense of the host which suffered in development and decreased in yield.

If such unilateral adaptation were possible, its results were likely to be that the parasitic fungi eventually overwhelmed the host. However, even the fungi most vigorous in their parasitism such as

Phytophthora infestans, which under favourable conditions may kill the plants attacked, have hardly ever been able to endanger the continued existence of the host species as a whole. Other fungal parasites do not usually threaten the life of the individuals infected, though they may reduce the production of organic matter and especially of seeds. No case is known of a vegetable parasite eradicating the species attacked in its entirety, for that might obviously involve eradication of the perfectly adapted parasite itself.

Phytopathologists distinguish at present in each host species a peculiar natural passive force of resistance ("Resistenz" after Gæumann) and an active force of resistance called immunity. The latter becomes effective only when the fungus is already invading the host or has succeeded in doing so to some extent. Similarly, each species of parasitic fungi is considered to possess a specific aggressive force (power of germination and penetration) and to be capable of endosomatic spreading to a greater or lesser degree.

The difference between the resistant forces of the host and the aggressive forces of the fungus is termed virulence (after Gæumann). Of all the numerous parasitic fungi only a few or a single species, or even only a certain spore form, may be virulent in respect of certain plant species, and this virulence may further be limited to certain seasons (e.g. in the *Uredineae*). It follows that the plant is capable of a d m i t t i n g or r e s i s t i n g a certain fungus, a fact to which we shall return below.

Granted the possession of considerable powers of resistance and immunity on the part of the host, it is not readily understood — if endosomatic fungal invasion is really entirely harmful and effected only by overcoming these powers — why the powers of defence have not increased in the course of time so as to render attack by parasitic fungi an exceptional phenomenon. As a matter of fact we observe the reverse: the families of parasitic fungi are extraordinarily rich in species which live endosomatically on a similarly large number of species and families of higher plants. Structural and functional adaptation of these fungi to cohabitation with their hosts has progressed so far that it is indicative of long periods of phylogenetic development in close relations that are reciprocal rather than hostile.

We thus consider it evident that the relations between the host plants and their fungal cohabitants are conditioned by powers other than those of aggressiveness and resistance. We therefrom derive our hypothesis that s p e c i e s o f g r e e n p l a n t s a s a r u l e t e n d t o a d m i t o n l y t h o s e f u n g a l s p e c i e s w h i c h a r e c a p a b l e o f c o m p e n s a t i n g the plants for the n u t r i e n t s t h e y p r o v i d e, a r e n o t e n t i r e l y h a r m f u l, a n d w i l l n o t e n d a n g e r the continued existence o f t h e p l a n t a s i n d i v i d u u m o r s p e c i e s.

The essential criterion for the understanding of relations between host and fungus is not the injury inflicted by one to the other.

Decisive importance thus attaches to the ratio of benefit to injury experienced by either of the cohabitants. Our theory postulates that all cases of cohabitation between plant and fungus constitute symbiotic relationships. These are not as balanced as in perfect synsomatic lichen symbiosis or in mycorrhizal symbiosis. As mentioned above, the plant in most cases enjoys the advantage of preserving intact its independence of form, function and life-sphere, while the fungus enjoys the nutrients derived from the plant. We maintain further that each fungus is bound to benefit its host in some ways, otherwise the plant would not admit its penetration or spread in its body. Without this compensating relation the phenomenon of parasitoid symbiosis and the variety of its naturally occuring forms does not appear plausible.

We are unable to accept the definitions of parasitism and symbiosis preferred by EDUARD FISCHER and ERNST GAEUMANN in their "Biologie der pflanzenbewohnenden parasitischen Pilze":

„Symbiosis liegt dann vor, wenn das Zusammenleben zwischen dem Pilz und dem anderen Organismus beiden Partnern einen Vorteil gewaehrt. Parasitismus liegt dann vor, wenn der Pilz allein den Nutzen zieht und den Organismus, von dem er seine Nahrung erhaelt, mehr oder weniger schaedigt."

FISCHER and GAEUMANN (6) recognize the transitions between the concepts of parasitism and symbiosis and refer in this connection to the perfect symbiosis. Yet their categorical aproach has been instrumental in the *a priori* exclusion of the aspect considered crucial for our hypothesis, viz. the benefit the host may derive from the invading fungus. This explains the lack of phytopathological studies in this direction and the consequent lack of knowledge required to argue this point in the field of plant pathology.

However, in the field of medical pathology the study of bacteria has for obvious reasons advanced further. We refer to the more recent discoveries of the benefit derived by higher animal organisms from localised intestinal symbiosis with *Bacterium coli.* The intestine provides the nutrients for *B. coli,* much as the plant provides for the fungus; it is able to do so without undergoing any changes, again just as in the plant-fungus relation. *B. coli,* on its part is structurally too limited for marked potential changes, nor are these required for its purely physiological function. This bacterium was previously considered a perpetual parasite of the intestines of man and other mammals, without benefitting the host in any way. It is now known that *B. coli* not only enables cellulose digestion in the intestines to proceed normally, but also plays an essential part as symbiont in two other directions.

But this beneficial symbiotic character attaches to *B. coli* only while in the intestines. If, under abnormal conditions, the bacterium reaches other organs it proves most injurious to the latter and to the organism as a whole.

B. coli thus constitutes a strictly localized symbiont currently admitted and supported by the intestines but not by any other organ. If other organs are invaded, they are unable to contain the development of the bacterium within the desirable limits because of the far-reaching adaptation to the organism it has achieved in the course of intestinal symbiosis. The essential condition for the intestinal development of *B. coli*, in preference to other organisms, must be considered to lie in the benefits its localized action there conveys to the higher organism.

Where plants bar the admission and development of an invading fungus, this may be due to the latter being incapable of rendering compensatory services. Nor could the fungus in this case be expected to undergo phylogenetic transformations in structure and function to an extent comparable with the fundamental adaptations of "parasitic" fungi. A continuity of mutually beneficial relations appears to be necessary even for unilateral adaptation of these fungi to their host.

That each species of plants is capable of admitting or resisting invasion by a certain type of fungus or spore is particularly evident in those highly specialized *Uredineae* with which we deal elsewhere (5b; 7). Numerous closely related species of *Uredineae* are very widely distributed; but although the air currents mainly responsible for spreading the spores deposit the latter uniformly over all the plants in the region, only certain definite species will admit invasion of a fungal species which, in its turn, may or may not be equally limited in its choice of hosts. The plant has three ways of obstructing invasion, viz. by preventing spore germination or penetration of germ tubes, or by containing the invader at the point of penetration.

Each species of rust fungi possesses from two to five forms of spores. In the rusts developing on alternate hosts one form of spores is admitted by only one or several definite species of plants while the other spore forms can only develop on other equally definite species. But each spore form is often admitted by its host species only at certain seasons. This detailed regulation of mutual relations could not be imagined unless the hosts themselves participate symbiontically in the process of invasion.

ii. *Mycorrhizae and their significance for parasitoid relationships*

In their chapter on "aktive Formen der Widerstandsfaehigkeit der Pflanzen gegen parasitische Pilze", Fischer and Gaeumann (6) also refer to the formation of mycorrhizae as indicating "dass die Wirtspflanze als Reaktion auf die Infektion durch den Mykorrhiza-bildenden Pilz fungicide Stoffe ausscheidet, die den eindringenden Parasiten unmittelbar schaedigen".

The historical processes concerned in these infections are likewise considered to constitute an active defence of the plant body. At the end of this chapter these authors summarize their conception as follows:

"Die Naehrpflanzen warten also nicht, Gewehr bei Fuss, ab, was der Parasit mit ihnen beginnen wird, sondern es erhebt sich zwischen ihnen und dem Parasiten ein Kampf, dessen Ausgang nicht nur von den Verhaeltnissen abhaengt, wie sie vor der Infektion in der Wirtspflaze gegeben waren, sondern auch von den Kraeften, die waehrend der Infektion, d. h. waehrend des Kampfes, in ihr und durch sie mobilisiert worden sind."

They further conclude:

"Es muesste also auch auf dem Gebiete der Pflanzenkrankheiten neben der chemischen Immunisation eine biologische (durch Vaccinierung) moeglich sein."

The evidence adduced by FISCHER and GAEUMANN to show that even in the perfect symbiosis of mycorrhizal development the plant is capable of mobilizing materials for an "active defence" is of significant importance for our hypothesis of parasitoid symbiosis. It shows that admission of the fungus and its endosomatic development is effected only where the plant tolerates it. This tolerance can, in our view, have its causes only in the usefulnes of such cohabitation.

The hypothesis of mutual benefit, though never subjected to phytopathological study, has found support — apart from the perfect lichen symbiosis and the symbiosis of *Leguminosae* with their root nodule bacteria — in the mycorrhizal symbiosis of *Calluna* with the fungus *Phoma* [RAYNER (9)] and in the mycorrhizae of orchids (10). But notwithstanding the advantages derived in these cases by the plant from its symbiont, FISCHER and GAEUMANN, while recognizing this as a special case of fungal invasion, yet maintain their above conception of the constant struggle of the two types of organisms against one another.

In the mycorrhiza of *Neottia Nidus Avis* and *Corallorhiza* we are even confronted with a case where the fungus plays the rôle of host and provides the nutrients, while the higher plant is the "parasite". Here the plant has undergone pronounced changes from its former forms and functions; it has lost or greatly reduced its leaves, water-conducting system, chlorophyll bearing organs, and endosperm in the seeds, but has retained its original characters of fruit and flower formation, just as these characters can always be clearly recognized in the "parasitic" fungi, whether *Basidiomycetes* or *Ascomycetes*.

iii. *Effect of parasitoid fungal symbionts on the plant species as a whole*

In considering the effect of a fungus on its host we further have to distinguish between the effect on the individual plant concerned and the species of this plant as a whole. That the individual plant is often harmed by the fungus is too evident to require discussion. But the effect of the fungus on quality of the seed, and especially on the consequent maintenance and perpetuation of the species, is an entirely different problem which cannot yet be assessed satisfactorily.

Plants as a rule produce an excess of seeds of which only a

small proportion actually serves to perpetuate the species. A reduction of such seed production does not, within certain limits, involve an adverse effect on this process of perpetuation.

While studying flower infections of barley and wheat by *Ustilago* smut fungi, with the aid of the brush or cylinder infection technique, we observed that especially those kernels succumbed that had failed to develop to a normal weight (2). With the use of such grains we were able to obtain a 100 percent. infection of plants in our experimental plots. Under natural conditions this would result in constant selection of the strongest and most resistant grains; in fact, in our experiments it required careful treatment (sowing in frames and subsequent transplanting) to prevent the plants from fully infected seed from being suppressed by their more vigorous uninfected competitors.

In the experience of several centuries no fungal parasite has ever been known to eradicate its host. Thus the rust and smut fungi have undergone so fundamental an adaptation that not only new species and genera but also new, sharply defined families and classes have arisen in a process undoubtedly extending over long phylogenetic periods. Nevertheless not a single one of these fungi has eradicated its specific host, as that would have implied discontinuation of its own existence.

We may thus conclude that normal fungal attack does not result in the displacement or destruction of the plant species concerned and is not antiphytobiontic in character.

iv. *Competition between higher plants as compared with parasitoid symbiosis*

In contrast to the manifold and frequent symbioses between parasitoid fungi and higher plants, it is relatively rare for one such plant to invade the organs of another plant species and to draw all its nutrients from the latter. These plants, according to our theory, cannot benefit each other to an extent warranting a fully symbiotic relationship.

Neither the soil nor the air space occupied by one plant can simultaneously serve another plant, though there are of course ecological plant associations in which various species grow in close conjunction with one another. Fungi, on the other hand, do not restrict the soil or air space available to their hosts, nor do they in general affect their light requirements. On the contrary, they even provide the plant with an essential nutrient, carbon dioxide, and thus partly make up for the nutrients they may withdraw from the host. It is worthy of note that higher plants are much better equipped to prevent the germination, penetration and spreading of fungi in their tissues than to stop the growth of other competitive plants in their immediate vicinity. This is particularly true of young plants. We may therefore assume that far more plant species are weakened and eventually eliminated by the competition of other plants (espe-

cially of more highly developed strains or more vigorous species) than by the action of fungi; but the label of destructiveness or parasitism has never been attached to such competitive plants.

This also applies to the higher organisms in the animal kingdom. In their competitive existence higher animals certainly inflict on each other injuries far exceeding those caused by the worst of their lowly parasites.

v. *Conclusions concerning parasitoid fungal symbiosis*

Summarizing the above argument, we repeat that the far-reaching adaptation of fungi to their hosts over a long period of phylogenetic development decidedly tends to indicate that the effect of the fungus on the host cannot be purely detrimental or parasitic in the accepted sense.

The facts brought out in mycorrhizal and other mycological research, that green plants possess a powerful mechanism for their defence against fungal invasion, and that these defence forces are n o t called into action only where a specific type of fungus seeks admission, further strengthen our view that this phenomenon is based on a mutually beneficial association.

Though the benefits derived by the host plants from numerous cases of parasitoid symbiosis have not so far been determined, we stress the significance of the case of *Bacterium coli* to which other cases in the field of animal pathology could be added. We further note that in the symbiosis of *Neottia* and *Corallorhiza* it has likewise so far not been possible to determine the benefit derived by the root fungus from its higher plant "parasite".

Viewing the plant not as an individual but as a species, it is noteworthy that no plant has ever been known to be exterminated by a fungal parasite. On the contrary, in certain cases, such as that of some smuts, the destruction of weak propagation material by the fungus may help to strengthen the species by a process of selection.

In conclusion, we summarize our views in the following theorem: The variety of forms and functions exhibited by the parasitoid fungi in the multitude of their species, genera, families, and classes (*Uredineae, Ustilagineae* etc.) has arisen in long periods of phylogenetic development in a symbiotic association with plants that is of some mutual benefit. It is not the product of an age-old struggle in which the host species has unilaterally suffered and will continue only to suffer.

In our "General Principles of an orbis-vital System of Fungi", of which the present paper forms a part, a later chapter on "Antibiosis" will deal with the antibiotic processes in organisms struggling with each other. This will be succeeded by a critical consideration of the cytosymbiotic and somatosymbiotic processes of life as compared with the antibiotic processes.

Acknowledgment

The author has pleasure in acknowledging the valuable help rendered by J. PALTI B.Sc. in the accurate translation of this paper, which involved in some instances the creation of English counterparts to the new concepts expounded in the original German manuscript.

Professor H. R. OPPENHEIMER very kindly suggested some of the terms employed here.

SUMMARY

A distinction is made between the cytosymbiosis constituted by intracellular linkage of two kinds of chromosomes or nuclei and the somatosymbiosis of endosomatic cellular unions within a single individual or of exosomatic relations between separate individuals. The various types of such symbiosis are discussed in detail.

Special attention is paid to the relation between the fungi usually termed "parasitic" and their hosts. It is concluded that this relation, instead of being unilaterally harmful to the host, is likely to be in certain respects mutually beneficial to the two organisms. This argument is supported by facts established in studies on mycorrhizae and in the field of animal pathology (*Bacterium coli*) and by considerations of the effect of fungal invasion on plant species as a whole.

REFERENCES

1. BONNIER, (1889). Recherches sur la synthèse des Lichens. — *Ann. Soc. Nat.*, 7. Ser.
2. BREFELD, O., & FALCK, R. (1905). Die Blueteninfektion bei den Brandpilzen und die natuerliche Verbreitung der Brandkrankheiten. — *Brandpilze* (Hemibasidii), IV, 13. Heft.
3. FALCK, R. (1910). Die Lenzitesfaeule des Coniferenholzes. — *A. Moellers Hausschwammforschungen*, III, no. 32, pp. 1—234.
4. FALCK, R. (1912). Die Meruliusfaeule des Bauholzes. — *A. Moellers Hausschwammforschungen* VI, no. 16 : 405 pp.
5. FALCK, R. Grundlinien eines orbis-vitalen Systems der Fadenpilze, Teil III : (a) Das *Oidium Merulei reversibile* und das *Oidium Merulei irreversibile*. (in print).
   (b) *Uredineae* and *Ustilagineae*. (in print).
6. FISCHER, E., & GAEUMANN, E. (1929). Biologie der pflanzenbewohnenden parasitischen Pilze. Jena.
7. KLEBAHN (1904). Die wirtswechselnden Rostpilze. Berlin.
8. MOELLER, (1887). Ueber die Kultur flechtenbildender Ascomyceten ohne Algen. Muenster.
9. RAYNER, M. C. (1915). Obligate symbiosis of *Calluna vulgaris*. — *Ann. Bot.* 29.
10. RAYNER, *M. C.* (1925). The nutrition of mycorrhiza plants. — *Brit. Journ. Exp. Biol.* 2.
11. STAHL, E. (1877). Beitraege zur Entwicklungsgeschichte der Flechten. Leipzig.

ON THE CLIMAX-VEGETATION OF THE NEGEV

WITH SPECIAL REFERENCE TO ARID PASTURE-PROBLEMS

By H. BOYKO,
Ecologist, Division of Research, Extension, and Agricultural Education;
Ministry of Agriculture, State of Israel.

I. INTRODUCTORY NOTE

The author has been entrusted with the task of undertaking a plant-sociological survey of the Negev, i.e. the semi-desert and desert-area forming the Southern district of Israel.

Purpose and aim of this survey is to find out the ecological foundations for an adequate land-use and colonisation of these vast and mostly unexplored stretches.

In the course of these investigations, undertaken primarily to find quantitative indicators to serve as a basis for hydrological research work*), the attention also focussed on the problem of pasturing, and some relevant observations are dealt with in this paper.

II. THE FEATHERGRASS AREA

When we proceed through the extended areas of loess around Beersheva further South-East into the Far-Negev and the Wadi Araba, we again and again meet the typical arid half-desert pastures, which — as in all similar regions of the globe — are nearly always composed of more or less sparse shrub associations. Only in the North of the Negev, in the mountains up to Ras Raman and on the mostly loess covered high-plateaux, we find the remnants of a feathergrass steppe, which indicates a less arid climate. A preponderating part play here the taller species of *Aristida* and *Stipa* of the *barbata* group.

In this northern region are concentrated those typical sand and loess areas where precipitation still averages about 200 mm.

A large portion of these plains is ploughed or used for pasturing, and all these lands, including the slopes of hills, are severely overgrazed. This overgrazing, practised for at least several centuries, lead to the impression that certain unpalatable shrubs and perennials play a dominent rôle; actually, they outweigh the natural climax association of the feathergrasses. The circumstance that in the course of the recent war grazing by herds of the Beduins was interrupted or at least greatly reduced, has permitted these grasses to recover slightly at a number of localities. Plate I, fig. 1, and table I, present such a

---

*) In particular, we endeavoured to establish isohyetes based on the distribution of vegetation, as well as depth and horizontal extension of groundwater levels by plantsociological methods. [cf. BOYKO, H. (1949/50). Plant sociological research as preparatory work for hydro-engineering projects in arid areas (in press)].

feathergrass steppe, composed principally of *Stipa Fontanesii* and *Aristida ciliata*, near Bir Rahme, southwest of Kurnub.

TABLE I.

Remnants of the Feathergrass steppe

Locality: Bik'at Rahmet, 525 m. above sea level; flat; size of plot: 10 m²; vegetation cover: 60%; Date: 31. V. 1949.

(*Stipa* and *Aristida* have somewhat recovered thanks to the interruption of grazing during the war).

Species	Abundance	Dominance	Sociability	Periodicity	prevailing height in cm
Aristida ciliata Desf.	4	3	2	fl.	60
Stipa Fontanesii Parl.	2	1	2	fr.	60
Asphodelus microcarpus Viv.	3	2	2	fr. dr.	100
Artemisia monosperma Del.	3	2	1	b.	30
Noea mucronata A. et Schw.	3	1	1	fol.	30
Allium sp.	3	1	1	fl.	15
Aegilops longissima Schw. et M.	3	1	1	fl.	40
Bupleurum lancifolium Horn.	1	1	1	fr.	6
Schimpera arabica H. et St.	2	1	1	fr. dr.	20
Adonis dentata Del.	2	1	1	fr.	8
Arnebia decumbens C. et Kr.	1	1	1	fr.	10
Atractylis flava Desf.	2	1	1	fl.	10
Hippocrepis bicontorta Lois.	2	1	1	fr.	5
Nigella deserti Boiss.	2	1	1	fl.	8
Astragalus peregrinus Vahl.	2	1	1	fr.	10

Abbreviation: b = budding; fol = in foliage; fr = fruiting; dr = dry; ass. = assimilating; fl = flowering.

We are here in an area where some Mediterranean fruit-trees are grown by Beduins according to a special system, viz. by accumulating the rain-water in depressions surrounded by small mud- and stone-walls. Plate I, fig. 2, shows such a site, most astonishing for the bypasser, where about half a dunam of land has thus been converted into a small fruit- und vegetable-garden.

One almond tree with abundant ripe fruit (June, 1949), five well-developed fig-trees, a luxuriant pomegranate with luscious fruits and one grape-vine made up this fruitgarden. On the soil between these trees, but not in their shade, we further found some squash, maize and water-melons which grew well.

In many of the flat wadis, even in their upper course, high up in the mountains, a similar method is practised by the Beduins for cereal growing (mainly barley but also a little wheat), making an effective use of the rain water. This is done especially well in the area of the ruins of Abdeh, the ancient Nabatean and then Byzantine town on the way from the Northern Negev to Ras-Ramân, where a large number of low walls is seen running cross-wise through the Wadis and damming the floods in terraces. The Beduins are still partly using the ancient terraces with walls of hewn stones and these walls

(see plate I, fig. 3) have apparently also served as a pattern for their own buildings.

III. ARTEMISIA HERBA ALBA COMMUNITIES

In this steppic region with relatively high precipitation, overgrazing results in the dominance of *Artemisia Herba alba* which covers nearly all the hills from 550 m. above sea level upwards in fairly dense stands (plate I, fig. 4).

With growing elevation above sea level and consequently decreasing aridity of the site, *Artemisia Herba alba* approaches the optimum of its ecological requirements. The almost mathematical exactitude with which this species follows the geo-ecological law of distribution is to be seen most strikingly by investigating its behaviour with regard to the IE-factor (IE = Insolation-Exposure). Near its arid borderline, — here 450—500 m. above sea level, — it is still, and exclusively, found on Northern slopes or on steeper slopes with Eastern and Western exposure. This *Artemisia* is thus an excellent quantitative indicator for a more humid environment (lower temperatures and/or higher precipitation). Its climatic optimum is indicated by relatively dense stands even on southern slopes with about 10° inclination. Such stands are found in the highest parts of the Negev, North of Râs Ramân, at altitudes from 800—1000 m. They indicate an average annual precipitation approximating 250 mm. The meteorologicol maps which so far indicated unduly low figures for this region, can for the future be based quite satisfactorily upon this plant as an indicator.

In this region we also found *Pistacia mutica L.*, the typical species as well as var. *atlantica* and transition forms. But this interesting tree*) cannot serve as a climate indicator because it occurs exclusively in wadis or on spots with comparatively large catchment areas, where much water collects from the slopes. Besides this locality we saw *Pistacia* also in the more than 100 m deep ravine near the waterfall of Ein-Murrah, which is only 420 m. above sea level. The mean precipitation there certainly does not exceed 150 mm. but the water course is quite near (plate I, fig. 5, 6).

On the borders of desert regions, such as those of the Negev considered here, the plant groups to be used for climate classification must be chosen with the utmost care. Here the correct understanding and designation of vegetation types is of decisive importance for every kind of land use, while small shifts in climate factors, without any significance elsewhere, may here become crucial for the existence and survival of plants (5).

Of the many records taken by the author to achieve this aim, a few are presented here as typical examples.

*) These trees were discovered in the Negev already in 1945 in the course of a remarkable and most difficult expedition on foot by a group of young botanists (KAUFFMANN, KUSHNIR, RIZIK, WAHRMANN and others, led by DANIEL ZOHARY).

TABLE II

Artemisia Herba alba communities in the Negev

No. of Square:	(1)					(2)					(3)						
Site:	Hills SE of Asluj, 500 m. above Sea-level																
Exposure:	N, 15—20°					NE, 5°					S, 10°						
Size:	2×2 m					2×2 m					2×2 m						
Vegetation cover:	30% (excluding Lichens)					10%					5%						
Date:	31.5.1949					=					=						
	Abundance	Dominance	Sociability	Periodicity	Height in cms.	Abundance	Dominance	Periodicity	Height in cms.		Abundance	Dominance	Periodicity	Height in cms.		Number of individuals in squares (2) and (3)	(not recorded in square 1)
																2.	3.
Asphodelus microcarpus Viv.	3	2	1	fol.	(15—20)	3	2	b	(15)		2	1	b	(15)		10	2
Aristida ciliata Desf.	3	2	1	fr, dr	(35)	2	1	fr, dr	(35)		—					2	—
Salvia lanigera Poir.	3	2	2	dr		2	1	dr			—					1	—
Noea mucronata A. et Schw.	2	1	1	fol			—				—					—	—
Dianthus judaicus Boiss.	1	1	1		(15)		—				—					—	—
Teucrium Polium L.	2	1	1	b	(20)		—				—					—	—
Phagnalon probably sp. n.	2	1	1	fl	(30)		—				—					—	—
Artemisia Herba alba Asso.	2	1	1	fr, ass	(20)	1	1	fr, dr	(10)		—					1	—
Tulipa amblyophylla Feinbr.	2	1	1	fl, fr	(12)		—				—					—	—
Gymnocarpus fruticosum Pers.	2	1	1	fl	(10)	2	1	fl	(20)		—					3	—
(with *Cuscuta* sp., fl.)	1	1	1	fl			—				—					—	—

Helianthemum vesicarium Boiss.	2	1	1	fr	(20)	2	1	fr	(8)	—				2	—
Gagea tenuifolia Boiss.		—				2	1	fr, dr	(7)	1	1	fr, dr		2	1
Centaurea aff. *aegyptiaca* L.		—				2	1	fl	(5)	—				3	—
Allium Artemisietorum Eig et Feinbr.		—				2	1	fl	(20)	2	1	fl	(15)	3	2
Reaumurea palaestina Boiss.		—				1	1	fol	(10)	2	1	fol	(10)	1	3
Fagonia grandiflora Boiss.		—					—			3	1	fr	(25)	—	4
Anabasis articulata Moq.		—				1	1	ass	(10)	1	1	ass	(10)	1	2
Astragalus peregrinus Vahl.	2	1	1	dr, fr	(10)		—			—				—	—
Chenolea arabica Boiss.		—					—			2	1			—	—
Stipa parviflora Desf.	1	1	2	fr			—			—				—	—
Foliose lichens on stones	4	3			(2—5)		—			—				—	—
Crustaceous stone lichens	3	2				4	4			?				—	—
Reboudia pinnata Sch.	3	1	1	fr		3	1	fr	(20)	2	1	fr, dr		13	3
Ononis breviflora Ser.	3	1	1	fr, dr	(8)		—			—				—	—
Carrichtera annua Asch.	3	2	1	fr, dr	(20)		—			—				—	—
Filago germanica Huds.	2	1	1	fr, dr	(2)		—			—				—	—
Erodium laciniatum Willd.	2	1	1	dr	(10)	1	1	dr	(5)	—				1	—
Bromus scoparius L.	3	1	1	dr	(10)	2	1	dr	(6)	—				2	—
Anthemis hebronica Boiss. et Ky.	2	1	1	fl	(15)	2	1	fol	(10)	—				6	—
Trigonella arabica Del.		—				1	1	fr, dr		—				1	—
Asteriscus pygmaeus C. et D.		—					—			2	1	fr, dr	(3)	—	4
Matthiola livida D. C.		—				3	1	fr, dr	(20)	—				3	—
Scleropoa memphitica Spr.		—				1	1	fr, dr	(15)	—				1	—
Koelpinia linearis Pall.		—				1	1	dr	(5)	—				1	—
Trigonella stellata Forsk.		—					—			2	1	dr	(2)	—	8
Stipa tortilis Desf.		—					—			2	1	fr, dr	(6)	—	4
Astragalus tribuloides Del.		—					—			3	1	fr, dr	(3)	—	24
Pteranthus dichotomus Forsk.		—					—			2	1	fr, dr		—	?
Statice Thouini Viv.		—					—			2	1	fr, dr		—	—

Remarks: 1). All species of the records (2) and (3) except lichens show degree of sociability = 1.
2). See also the table of Artemisia herba alba communities in No. 10 of the references.

Table II presents records from three sample squares near the limit of distribution of *Artemisia Herba alba* where it passes into the lower hill and loess area around Beersheba. All three have been taken on the same hill but with different inclination and compass directions. The strict adherence to the "Geo-ecological Law of Distribution" is so evident to anybody familiar with the flora that an exact analysis can be dispensed with here. The paramount effect of the IE-factor is very obvious: the first square shows an Irano-Turanian association with a strong Mediterranean touch. Here, if overgrazing could be eliminated, *Aristida* and *Stipa* would soon assume a leading rôle and build a feathergrass steppe. The third square is that of a typical Saharo-Sindian association, whilst the second is transitional between the two.

The remarkably well-developed foliose lichens (see plate II, fig. 7) indicate a relatively high precipitation which can be estimated on the basis of this and other indicators as approximately 175 mm. The most important fact is that *Artemisia Herba alba* occurs here with a relatively high abundance even on southern slopes up to 15°.

Table III presents records from a fourth sample-square which is, however, quite different from the former three described in Table II.

TABLE III.

Artemisia Herba alba — Haloxylon articulatum community

Watershed towards Wadi Fuqra, west of Abda; NE. 10°.

Plot: 10 m²; 480 m. above sea level; Soil loessy between (lime-) stones.

Artemisia in general 5—8 shrubs per m², more or less evenly distributed.

Species	Abundance	Dominance	Sociability	Periodicity	Number of individuals	Prevailing height in cm.	Prevailing width of bushes in cm.
Artemisia Herba alba Asso.	4	3	1	fr.	61	20	20
Zygophyllum album L.	3	1	1	fr.	2	40	50
Haloxylon articulatum Bge.	2	1	1	ass.	1	40	50
Noea mucronata A et S.	2	1	1	ass.	1	40	30
Annuals and perennials*) together	3	1					

*) The perennials are geophytes and some remnants of *Stipa* and *Aristida* tufts, grazed down to the soil-surface.

Here, too, *Artemisia Herba alba* occupies a dominant position. The good fodder plants have been eradicated or suppressed by overgrazing. *Zygophyllum* and *Noea* likewise are eaten by the grazing herds, particularly by goats, but their thorns offer them sufficient protection against extermination. The relatively rich vegetation cover in every exposition, except on soils with a high content of gypsum or in the areas with a crusty and polished surface, points to a considerable amount of precipitation.

Here many Beduins gather regularly every year, staying for several weeks or even months in winter and spring time. They cultivate stretches in the flat wadis with the help of a terrace system, built in the Byzantine era or even earlier (see plate I, fig. 3).

The feathergrasses are the only species among those indicated in the sample-square of table III which possess no organs of protection against grazing. With the highest probability these plants are to be looked upon as the dominant species of the climax association in this area.

The expansion of the small shrub-individuals of *Artemisia* with their strong and (for men) refreshing smell has obviously been furthered by overgrazing. By now they cover all the slopes here rather densely, with about 5 to 10 such small shrubs per square metre. This applies chiefly to slopes with a steeper angle (more than 15°). As a rule the horizontal stretches or the slopes with small inclinations are nearly void of vegetation on this soft, white Senonian limestone.

Closer investigations revealed, that this is due to the relatively hard, smoothly polished surface of the somewhat loamy soil of all stretches with a small angle of inclination. The rainwater runs off, being unable to penetrate, and consequently these sites dry up immediately after rainfall. Seeds are either washed off or blown off immediately and if they happen to germinate by any chance, for instance owing to a mechanical obstruction or to their own ability to penetrate into the soil (*Erodium,* etc.), the seedling dies a few hours after the rains have ceased. In these types of soil seeding in artificially made small holes, as proposed by the author, seems to promise good results and experiments in this direction should start as soon as feasible.

IV. THE EREMIC ASSOCIATIONS

Towards the more arid and hotter area, other shrubs dominate as a consequence of overgrazing, in the first line *Anabasis articulata.* For this species, even more than for *Artemisia Herba alba,* the assertion holds true that its dominance proves overgrazing over a long period.

Already in the area of Kurnub *Anabasis* appears as the clearly dominating shrub on several places. Exceedingly modest, and rejected by cattle it grows on sand and rock and represents one of the very few species, that persist, similar to *Zygophyllum dumosum,* in scattered individuals even on the Hamada, the particularly dry, truly desert-like, stony stretches with mostly hard-crushed surface. Only in the most distant South of the Negev it is replaced by *Haloxylon salicornicum,* which seems to be as little demanding in regard to soils as *Anabasis* but still more resistant to drought and heat. This *Haloxylon* appears even in Eilat, in the extreme South, on open dry localities where *Anabasis* can only survive in shady waterruns, or in similar localities.

V. SCALE OF THE CLIMAX ASSOCIATIONS.

Based upon the preceding considerations, we have tentatively established the following scale of climax associations in the Negev in dependence upon increasing aridity.

(1) A steppe of tall feathergrasses (*Aristideto-Stipetum*) upwards from 600 m. above sea level and with a precipitation of about 200—250 mm.

(2) A steppe of short feathergrasses predominantly of *Aristida plumosa* and *A. obtusa.*

This association points to a precipitation of about 150—200 mm, but temperatures here are somewhat higher, winds are fiercer, and therefore — even with a similar amount of rainfall — aridity is somewhat higher than in the area of the first-named climax vegetation.

(3) The following region evidently has a precipitation of less than 150 mm or even less than 100 mm as yearly average. *Calligonum comosum* and *Haloxylon persicum* are the two representatives of woody plants which would form a very sparse and low forest, or rather scrub, on the wide *sandy* areas with this strong aridity, provided there were no overgrazing. Such a potential "border forest" is established in the Tureibe area East of Kurnub and proceeds southwards far into the Araba (farther South than Wadi Gharandal). Of its components, *Haloxylon* demands even less soil moisture than *Calligonum.*

Here, on the border of a climate still supporting some kind of vegetation and of the real desert climate, the edaphic factors are too influential to allow the development of a uniform climax association. We distinguish therefore three subclimax associations:

(a) The above-mentioned sand association *Calligoneto-Haloxylonetum persici.*

(b) An association developing on the slopes of the limestone hills and on the slightly sloping "Hamada" area, exceedingly poor in individuals, wherein *Zygophyllum dumosum, Zilla spinosa* and several *Fagonia* species appear more frequently. We call it *Zilleto-Zygophylletum dumosi,* (*Zilla spinosa* can be regarded as the most characteristic species of this association. The ecological amplitude of *Zygophyllum dumosum,* however, is too wide, and its fidelity therefore too low to define that association by this species alone, although its abundance is mostly higher than that of *Zilla*).

(c) An association found in the flat gravel beds of wadis, which are often several kilometres broad, and also in waterruns, characterized by umbrella-shaped Acacias, mostly *Acacia Raddiana,* and therefore designated as *Acacietum Raddianae.* Towards the South of Wadi Araba, *Acacia spirocarpa* becomes more abundant.

Near springs or similar waterplaces the vertical extension of the various zonations, however, is clearly dependent upon the climate and gives us — by the method of the "shifts in amplitudes" (1) surprisingly exact quantitative indications for the climate as well as for the depth of the ground water level.

VI. THE ANABASIS ARTICULATA COMMUNITIES IN THE VARIOUS CLIMAX REGIONS

In all the above mentioned climax regions, with the exception of the first and in part of the last, we find as a rule *Anabasis articulata* as the leading shrub.

In the following tables a few examples are presented of such *Anabasis* communities from various climax regions.

TABLE IV.

Anabasis articulata-community from the climax region of short feathergrasses

Quantitative plant-sociological record of an overgrazed half-desert pasture (*Calligoneto-Anabasidetum*). Date: July 2nd, 1946.

Plot 400 m² (20×20 m.); 2 km. East of terraces Um-el-Hitam, East of Kurnub; inclination 5°; exposure: East; soil: sand, at least 60 cm. deep; vegetation cover: 40%.

Species	Abundance	Dominance	Sociability	Periodicity	Number of Individuals	Height in cm	Width in cm
Anabasis articulata Moq. Tand.	4	2	1	ass	23	30—60	50—100
Asphodelus microcarpus Viv.	4	2	1	dry	30	30—80	15—39
Retama Roetam Webb.	3	1	1	ass	3	50—70	70—100
Convolvulus lanatus L*)	3	1	1	fl	16	30—40	40
Thymelaea hirsuta Endl.	2	1	1	ass	1	120	50
Calligonum comosum L'Her	3	1	1	ass	5	125	140
Salvia aegyptiaca L. var. *glandulosa*	3	1	1	fr	1	25	15
Aristida ciliata Desf.	2	1	2	ass, fr	2	30	15
Stipa Fontanesii Parl.	3	1	2	ass, fr	10	40	15
Aristida obtusa Del.	4	2	2	ass, fr	412	10	10—20
Aristida plumosa L.	4	2	2	ass, fr	410	10	10—20
Avena Wiestii, Stipa tortilis, Trigonella arabica *Medicago spp.,* and other annuals as dry remnants	3	1		dry			

Some remarks should be added to this table: *Anabasis* benefitted to a high degree by overgrazing, being rejected by the herds of the Beduins (camels, sheeps, goats). The behaviour of horses and donkeys could not be observed sufficiently by the author. Similar benefits from overgrazing were derived by the second dominating species in this record, *Asphodelus microcarpus* as well as by *Retama Roetam* and *Thymelaea hirsuta.* Large stretches of such *Anabasideta* extend in a similar composition nearly throughout the entire Saharo-Sindian floral region, and a particularly important point seems to be that the relation between *Anabasis* and *Calligonum* gives us in many cases a good idea of the degree of overgrazing. Even more strikingly than in the Tureibe-area near Kurnub this overgrazing is pronounced

*) Fodderplants of high value for such half-deserts are spaced.

farther South in the Negev, where practically all the fodder shrubs have been eradicated by millenia of overgrazing although according to the Geo-Ecological Law of Distribution some of them might have taken their place in these plant-communities.

A record-square typical of this region, such as the one presented in another paper (5) from the Southern part of the Araba at Gharandal, contains not a single shrub or perennial other than *Anabasis*, although relatively many annuals are found there. Most probably it would not be too difficult to transform a large part of these *Anabasideta* from the desert border of Northern Africa and the Middle East again into relatively good pastures, as soon as man replaces *Anabasis* by fodder plants, shrubs and perennials of high quality and palatability. For such purposes the following species are primarily to be taken into consideration for the more arid areas: *Convolvulus lanatus, Argyrolobium uniflorum, Haplophyllum sp., Calligonum comosum, Panicum turgidum, Farsetia ovalis, Savignya parvifloru, Ochradenus baccata, Haplophyllum longifolium* and, last but not least, also the desert tree *Haloxylon persicum* (= *H. Ammodendron* in the larger species delimitation). This list is arranged according to increasing drought resistance.

Such a reclamation of half-desert pastures could probably be reached only by inserting the seeds mechanically by suitable machines into holes in the soil, about 2—8 cm. deep, before the winter rains start; otherwise the seeds will dry out a short time after the rain showers have induced them to germinate, and before they have yet had an opportunity of pushing their roots into deeper and cooler soil layers able to retain moisture for a prolonged period.

The observations which led to these conclusions were made by the author in the course of several excursions in the Negev area during the years of 1941, 1943, 1945, 1946, and 1949. It could be observed there and then, that only those seeds, which had been blown into such a hole, came to germination and subsequent development. Such holes were usually produced by animals, such as mice, lizards, snakes and insects. Man also sometimes chance to produce such holes, e.g. playing Bedu-children, depressions made by walking-sticks, etc.

How far we may be able to utilize the "pellets" or similar seed containers, made in America where they are sown successfully into desert areas by small planes, must be tried here by suitable experiments.

The sample-squares shown in our table from the North-Eastern part of the Negev have been collected in the course of pasture investigations and show at the same time the method of a "quantitative plant-sociological square record" during the starvation time of the vegetation period. If a sufficient number of such records is available as basic material, not only qualitative but also approximate quantitative valuations can be provided even of the many — often far remote — half-desert pastures which are covering large areas, on both sides of the equator.

It is essential that these plant sociological square-records be made with a high degree of accuracy, i.e. with records of both abundance and dominance, and in certain cases also of sociability. Combined with the afore-mentioned records and additional notes on palatability and dry weight of the species one is able to collect in a relatively short time quantitative data for the appraisal of the pasture capacity and the steps necessary for amelioration. It seems that the meat resources of the world could be considerably enlarged if we succeeded in an economical pasture management, based on plant sociological methods in the vast desert belts of the globe.

An experiment consisting essentially in the protection of certain areas from grazing for one or more years was carried out in this area by the district authorities. When investigated by the author in 1945/46, it raised hopes for a relatively quick success (2).

TABLE V.

Anabasis articulata community from the subclimax region of Zilleto-Zygophylletum dumosi.

Locality: between the hills South of Wadi Jirafeh; plot: 20×20 m.; nearly horizontal; soil: gravelly-sandy; vegetation cover 10%; Date: 3, June, 1949.

Species	Abundance	Dominance	Sociability	Periodicity	Number of individuals	Prevailing height in cms.	Prevailing width in cms.
Anabasis articulata Moq.-Tand.	3	1	1	fol	13	100	60
Ochradenus baccatus Del.	2	1	1	fl	2	100	120
Zilla spinosa Prantl.	3	1	1	fr	16	50	40
Gymnocarpus fructicosum Pers.	3	1	1	fl	7	30	30
Acacia Raddiana Savi	(2	1	1	fl)	*)	2 m to 3,5 m	
Reaumurea palaestina Boiss.	3	1	1	fl	8	20	30
Launea sp. (in the bushes of Zilla)	2	1	2	?	?	40	

*) The Acacias are scattered at irregular distances along a line in what seems to be the deepest part; on a stretch of approximately 200 m. there are 12 trees.

These 3 tables further show by the composition of the plant-community and their ecology that we are here confronted with several, quite distinct associations — in BRAUN-BLANQUET's sense — and even in the much broader sense of American ecologists — although in all of them *Anabasis* has reached a certain dominance. The often overwhelming dominance of *Anabasis* as consequence of overgrazing may easily lead a superficial observer to assume, that an *"Anabasidetum"* constitutes the climax association. That this is not the case emerges from the fact that *Anabasis* spreads through vast tracts of the Irano-Turanian as well as the Saharo-Sindian region and of the Sudano-Deccanian enclaves of the Negev.

TABLE VI.

Anabasis articulata community from the climax region of Haloxylonetum salicornici.

Locality: three kilometres South of Ein Daphyah; 20×20 m.; soil: gravelly sand; horizontal; vegetation-cover 10%; Date: June 4th, 1949.

Species	Abundance	Dominance	Sociability	Periodicity	Number of individuals	Prevailing heigth in cm	Prevailing width in cms.
Anabasis articulata Moq.-Tand.	3	1	1	ass	6	30	50
Haloxylon salicornicum Bge.	(2	1	1	ass	2	40	50
Acacia spirocarpa Hochst.	2	1	1	fol)	1	150	200
Savignya parviflora Webb.	1	1	1	fr, dr	1	20	30 (strongly browsed)
Eremobium aegyptiacum A. et Schw.	1	1	1	fr	1	4	
Zilla spinosa Prantl (a second specimen dead)	1	1	1	dr	1	10	10
Haplophyllum longifolium Boiss.	(2	1	1	fol)	1	10	30 (strongly browsed)
Ochradenus baccatus Del.	1	1	1	fl	1	30	80 (strongly browsed)
Panicum turgidum Forsk.	2	1	2	fr	?		

This is further corraborated by the fact that the valuable fodder plants which are suppressed, and nearly eradicated by overgrazing in normal years, reappear and recover now, after a preservation period of two winter seasons enforced by war conditions.

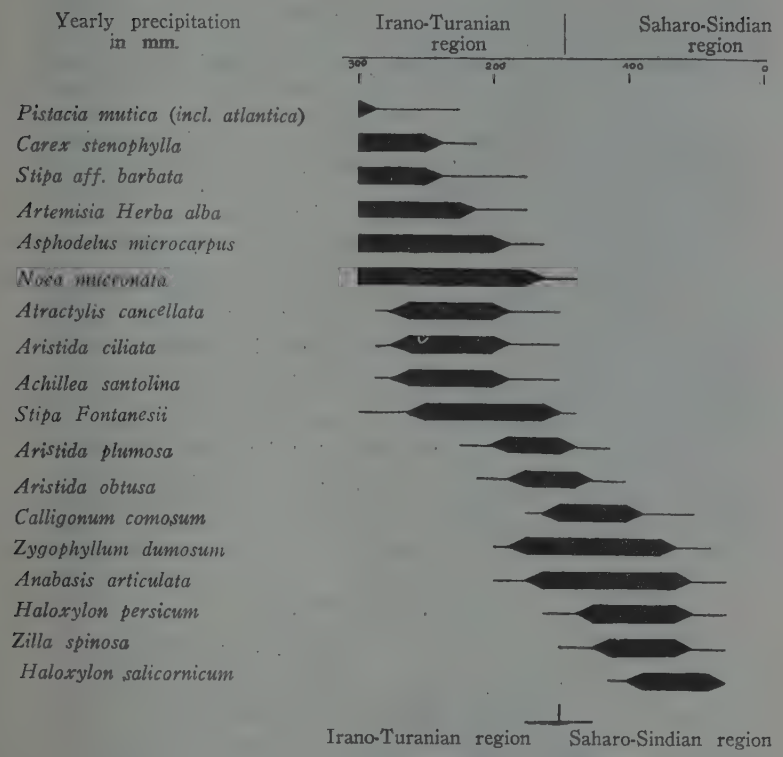
Genuine representatives of the real climax associations can be seen only in these species.

VII. INDICATOR SCALE OF ARIDITY

The area of Tureibe, southeast of Kurnub, forms a transitional region of intersection between the genuine Irano-Turanian and the Saharo-Sindian vegetation types. Here, on the way to the Araba even before the gigantic abyss of Ma'aleh Haakravim (Nakeb-es-Sufai) the valuable fodder shrub *Calligonum comosum* occurs for the first time, whilst the climate does not yet seem sufficiently arid for *Haloxylon persicum*. Down below in the Araba, where both these important woody plants are united in one association, *Calligonum* shows a distinctly higher moisture requirement.

Further South towards the successively drier regions, *Haloxylon persicum* associates with a shrub of its own genus, the much smaller *Haloxylon salicornicum*, the latter representing the most extreme indicator of aridity. A scale of drought resistance, with regard to a number of the most important plants of the Negev has been drawn up in the graph below. If we express the degree of aridity roughly by the decreasing total of yearly precipitation, the following picture results:

Fig. 1.: Scale of plant indicators for aridity
(Aridity roughly expressed by precipitation).



The above may be regarded as a checklist; it has therefore to be taken as a basis for further investigations, for interpolation of other species and for additional or rectified details for the plants concerned.

Legend : ■ = species growing in their optimum.
— = species growing only under favourable local conditions (e.g. southern or northern slope, watercourse, etc.).

VIII. THE HALOXYLON PERSICUM REGION — PRESENT, PAST AND FUTURE

Among the species of the above list one deserves our special attention. We refer to one of the altogether most interesting and important fodder plants of our area, the precious fodder tree of the

Asiatic deserts, of Persia, Sind and Arabia — *Haloxylon persicum* (*Haloxylon Ammodendron*).

Examining authentic specimens from Continental Asia, which have been determined as *Haloxyon Ammodendron,* and a large number of *Haloxylon persicum,* the author was unable to find any significant difference between the two species either in their anatomy or in other morphological characters. They are to be looked upon as varieties of the same species and probably have only been attributed independent identities because of their large geographical distribution. Without genetical investigations we cannot agree with the subdivision of species based only on such minute differences in the rudiments (!) of leaves as has been done in this case.

The ecological divergences between the Northern and Southern distribution areas are, however, not as important as they may appear at first sight. In both areas the tree grows only on sand and only in most arid localities. But the striking differences between the higher summer temperatures in the South and the lower winter temperatures in the North do not change the ecological conditions substantially. To see this we need only consider the differences in our small district between the *Haloxylon* stands east of Ma'an (Transjordan) at 1350 m above sea level with their low winter temperatures and the stands of Ghor es Safiya and North of Aqaba with their high summer maxima, and compare this total amplitude with that of the Inner-Asiatic region. Nevertheless a glimpse on the attached map of distribution shows that this Haloxylon species appears to have the *widest amplitude of temperature* of all the higher plants. (Fig. 2).

Fig. 2.: Distribution of Haloxylon persicum Bge. (×).

The Palestine plant, recognized by A. AARONSOHN (7) as the Ghada-tree of the Arabs, was correctly determined for the first time by H. R. OPPENHEIMER (7) als *H. Ammodendron* (according to the broader species concept). ZOHARY (8,9) determined it as belonging to the more narrowly limited *H. persicum*. The latter author also adds the following two plantsociological figures for the distribution of this desert tree in the Araba (the valley or, more correct, depression of 170 km length and 10 to 25 km breadth between the Dead Sea and the Red Sea).

Coverage 3 (i.e. 25—50% of the area).

Socialibity 3 (i.e. in troops, small patches, or cushions).

These figures need correction. It is obvious that the coverage of *Haloxylon persicum* in this desertic region in relation to the large area of the whole Araba is not even $1^0/_{00}$; this would mean the plantsociological figure to be 1 (=less than 5%). Table VII shows one example of our numerous records for a sample square of 20 by 20 m. and gives some quantitative data of one of the *densest* stands found there.

The second statement likewise demands a correction.

We are confronted with loose stands of the tree, each stand spreading over several square kilometres. These few stands are scattered over this rather bare area of the Araba comprising in turn several thousands of square kilometres. But the plant sociological meaning of the term "in troops" is quite different. It is meant to visualize the grouping of individuals on a restricted space as the consequence of a specific manner of propagation. Its inadequacy in our case is demonstrated by photo No. 9, Plate II. The following characteristic sample-square (Table VII) and the pictures give some idea about the actual distribution of the single individuals in this association. If a figure for sociability needs to be used in this case, it has to be 1.

TABLE VII.

Haloxylon persicum-stand between Gharandal and the main way to Eilat. 20×20 m.; Sand; plant-dunes about ½m. height; vegetation-cover; 10%; Date: June 3rd, 1949.

Species	Abundance	Dominance	Sociability	Periodicity	Number of individuals	Height in cms.	Prevailing width in cms.
Haloxylon persicum Bge.	3	2	1	ass	6	180	250
Calligonum comosum L'Hér.	2	1	1	ass	1	150	180
Calligonum (a dead specimen)						50	200
Zilla spinosa Prantl	2	1	1	fr		30	
Asphodelus tenuifolius Cav.	2	1	2	fr		25	
Plantago ovata Forsk.	3	1	1	fl, fr		5	
Neurada procumbens L.	3	1	1	fr, dr		5	
Savignya parviflora Webb.	1	1	1	fl, fr		30	
Peganum Harmala L.	2	1	1	fr		5	
Pulicaria undulata Kostel.	2	1	1	fl		30	
Schismus arabicus Nees	2	1	2	dr		10	
Lavandula coronopifolia Poir.	2	1	1	fl		60	

In all of the few remnant stands of *Haloxylon persicum* the invidual specimens are scattered more or less evenly over the area and any higher sociability is prevented by root competition. The cause of this manner of distribution emerges from photo No. 8: Not only the vertical but also the horizontal portion of the root-system of *Haloxylon persicum* as well as of *Calligonum comosum* is very extensive and root competition on this poor sandy soil is very strong under the existing extremely arid climatic conditions.

For natural regeneration it suffices if rainfloods occur once even in a few hundred years and drench the soil thoroughly, or if sufficient rains fall in two or more consecutive years and permit not only the seeds to germinate but also the quickly penetrating roots to reach moisture in deeper layers.

The author has long been convinced that the tree has only been suppressed by overgrazing. It appears mainly where the walking disstance from one well to the next is long and where consequently wandering herds and caravans must hurry in order to reach the next spring before nightfall. Our search for old individuals when based on this assumption, was surprisingly successful. Three huge sand-dunes, 4, 4½ and 5 metres high, respectively, proved to be overblown and half-buried remains of such old giants, as we had already suspected from the passing car (photo 10). Some parts of these majestic stumps and twigs still pierced the sand. The probability that such remnants may be found has been pointed out before (4), and a number of very old tree specimens of various other species have been mentioned in our regions, aged a thousand years and more. One of the stumps (or root-remnants) of our species showed a diameter of 160 cm. Considering an annual average diameter increase of *Haloxylon* of ⅔ to 1 millimeter this would indicate an age of 1600—2400 years.

But *Haloxylon persicum* forests of such old trees with a height of more than 5 meters and a DBH (=Diameter at Breast's Height) of 1—2 m cannot have been destroyed by goats alone; they must first have been cut by men. Subsequently the sprouts must have been overgrazed through hundreds of years. It seems most probably that the ancient copper mines of King Salomon, found in the vicinity, with their enormous demand for charcoal originally created the demand for wood in the neighbourhood*). It has to be added in this connection that *Haloxylon Ammodendron* including *A. persicum* is the "Saxawl" of

*) A rough calculation shows that the amount of *Haloxylon* wood in the virgin stands might have been enormous. The three sand dunes mentioned with the eldest remainders are spaced at a distance of approximately 20 metres from each other. In a forest of such spacing, there would have been about 10 m^3 wood per dunam, assuming two to five large trees delivering 2—3 solid metres each. A rough estimate shows that 100,000 dunams sand covered by such a virgin stand of *Haloxylon* trees in the Araba may easily have yielded the amount of 1 million (!) solid metres of wood for charcoal.

the Central Asiatic deserts and that for time immemorial the wood of this tree is used there as well as here by the nomads because of its hardness and suitability for charcoal production.

The evidence obtained shows that this valuable fodder-tree is the dominant plant of a climax association. Since we are, moreover, informed that Saxawl stands have been successfully established in Central Asia and Sind, by planting, we arrive at the conclusion that its large scale artificial re-establishment in its original area of distribution is highly recommendable. Apart from the high value of the wood, this would greatly increase the grazing capacity as well of the Araba as of many other desert regions in the Arab countries of the whole Middle East. More thorough excavations which could not be carried out during this short general survey and which are planned by the author for the next expedition, may yield definite data on the age of these old trees. They will also prove helpful in establishing whether the living branches protruding on both sides of the dune are part of the old individual or not. In any case, it can be definitely stated that the *Haloxylon* stands are the sub-climax association of all sandy soils between the Red and the Dead Sea and that only overgrazing has suppressed them so strongly. Consequently *Anabasis articulata,* worthless as fodder plant, has taken its place in the North, whilst *Haloxylon salicornicum* substitutes it in the South of the Araba.

IX. SUMMARY.

The present dominance of the most frequent species in the southern parts of Israel (the Negev and the Wadi Araba) is the result of severe overgrazing during many centuries. Thus in the less arid regions *Artemisia Herba alba* communities, and in the more arid regions the *Anabasis articulata* communities developed to their present stage.

Based on these considerations and detailed plant sociological records (some of which are presented as examples) an outline of the climax vegetation of these areas has been attempted which is divided into the following climax associations (climax regions):

1.) A steppe of tall feathergrasses (*Aristideto-Stipetum*) in the region with about 200 mm. yearly precipitation or more.

2.) A steppe of short feathergrasses (*Aristidetum obtusae*), in the region with about 200 to 150 mm yearly precipitation.

3.) The climax vegetation of the region bordering the desert *sensu strictiore* with less than 150 mm. yearly precipitation has to be subdivided into three subclimax regions, according to the influence of edaphic factors which have here become decisive. These subclimax associations are:

(a) *The Calligoneto-Haloxylonetum persici* (on sand);
(b) the *Zilleto-Zygophylletum dumosi* (on slopes and hamada plains);
(c) the *Acacietum Raddianae* (in the flat gravel beds of wadis).

4.) The genuine desert vegetation in the South is characterized by *Haloxylon salicornicum.*

Oases, because of their indirect relations with the climax vegetation, are not dealt with here.

The ecological features of *Haloxylon persicum* are discussed in more detail and the discovery of three individuals about 2000 years old is described. The macro-distribution of *Haloxylon persicum,* illustrated by a map, reveals an astonishingly wide ecological amplitude with regard to temperature, perhaps the widest among higher plants.

An attempt has been made to set up a biological scale of degrees of aridity by plant indicators (see graph).

Pasture problems are dealt with from various points of view, and problems of rehabilitation of half-desert areas are discussed.

REFERENCES

1. Boyko, H. (1945). On the need of an international network of plant sociological stations. *Chron. Bot.* 9:86—88.
2. Boyko, H. (1946). Report on arid pasture investigations, executed in Tureibe range, East of Kurnub. Distributed as manuscript. Govt. of Palestine, Jerusalem.
3. Boyko, H. (1947). On the rôle of plants as quantitative climate indicators, and the geo-ecological law of distribution. *Journ. of Ecol.* 35 (1—2): 138—157.
4. Boyko, H. (1947). Science and erosion problems in the Middle East. *Journ. Middle East Soc.* 1 *No.* 3—4; 22 pp.
5. Boyko, H. (1949). On climatic extremes as decisive factor for plant distribution. *Pal. Journ. of Bot.,* Reh. Ser. 7.
6. Braun-Blanquet, J. (1932). Plant Sociology. Translated by G. D. Fuller and H. S. Conard.
7. Oppenheimer, H. R. (1931). Reliquiae Aaronsohnianae I. Florula Transjordanica (avec les journaux de voyage d'A. Aaronsohn), *Bull. Soc. Bot.* Genève 22:1—301, Genève 1931.
8. Zohary, M. (1949). On the ghada tree of Northern Arabia and the Syrian Desert. Pal. Journ. of Bot. Jer. Ser. 1:413—416.
9. Zohary, M. (1944). Outline of the vegetation of Wadi Araba, *Journ. of Ecol.,* 32:204—213.

EXPLANATION OF PLATES

PLATE I

(1) Featherglasses rapidly regenerating after two winter rest without grazing. Bir Rahme, 550 m. above Sea level. Date: 3, June, 1949.

(2) A fruit and vegetable garden of Beduins, in the semi-desert South of Beersheba. An earthern wall gathers the run-off from a relatively large catchment area. 28, May, 1949.

(3) Byzantine terraces of hewn stones in the wadi-beds near the ruins of Abdeh. 4, June, 1949.

(4) Artemisia Herba alba covering the hills South of Abdeh. 600 m above Sea level. 4, June, 1949.

(5) Pistacia mutica (var. atlantica) on and partly in a dry watercourse of Wadi Nafkh (note the broken shadow). GBH. (Girth at Breast Height) of this tree is 6 m (!). 725 m above Sea level. 3, August, 1949.

PLATE II

(6) Pistacia mutica (var. atlantica?) in the ravine near the spring of Ein Murrah, 400 m above Sea level.

(7) Foliose lichens in the hills South of Beersheba, Northern slope 20°, 500 m above Sea level. 28, May, 1949.

(8) Horizontal roots of *Calligonum comosum* and *Haloxylon persicum* washed free by floods. The exposed piece (—) is 4 m. long. 2, June, 1949.

(9) A *Haloxylon persicum* — "forest" near Gharandal in Wadi Araba. The two bigger dunes cover the remnants of very old individuals. (see No. 10).

(10) A Haloxylon tree, as in (9), probably about 2000 years old, partly by sand. Where it emerges from the surrounding dune, it has a diameter of 1,60 m. 3, June, 1949.

(11) On the borderline of steppe and desert. Outlook into the desert mountains South of *Nakb Ghareb*. In the foreground bushes of *Zygophyllum dumosum*. This Saharo-Sindian species grows here, at 500 m. above Sea level, together with remnants of a declining steppe vegetation. 4, August, 1949.

Photos taken by H. Boyko, E. Boyko and N. Kauffmann.

FROST EFFECTS ON VEGETATION IN 1948/1949

By H. R. OPPENHEIMER

Division of Citriculture and Agricultural Botany, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

I. WEATHER CONDITIONS

While light radiation frosts often occur in the coastal plain of Israel, injurious "freezes" are rather rare. In the last decades after 1920 we know of their occurrence only in the winters of 1924/25 and 1931/32, when citrus plantations suffered serious damage.

The present report deals with frost effects observed by the author in the recent cold winter of 1948/49 in the neighbourhood of Rehovot. As we were informed by the Meteorological Service of the Government of Israel, the cold period was more extensive and temperatures lower than on any previous occasions in the present century.

The winter was extremely wet. Total precipitation reached at Rehovot 824.3 mm instead of an average of about 500. Polar air masses invaded the country in the rear of rain bearing cyclones during the first decade of January and again in the second decade of February, 1949. During the nights the sky was clear and the air dry and calm, favouring the accumulation of cold air in low places. Here, wild herbs and vegetables were repeatedly found covered with hoar-frost in the early morning and citrus plantations suffered heavy damage by the low temperatures.

Records of temperature in meteorological huts mean little under such conditions. At the Research Station of Rehovot, temperatures did not fall below zero, but Dr. K. Mendel who has on similar occasions observed a gradient of about 7° C between the hut of the station and the adjacent lowlands, assumes that during the coldest nights temperatures fell as low as -5° C. The damage on plants observed by us and others seems to support his assumption.

The Meteorological Service of the Government of Israel informed us that, to the best of their knowledge, no measurements of temperatures near the surface of the soil have been carried out, throughout the coastal plain, during the nights of the freezes. It seems therefore not unimportant to state that we have recorded temperatures of -2.7°C and -1.7°C at sunrise in a low and open locality (but not at the bottom of depressions) in the colony of Rehovot on January, 8th and February 19th, resp., about 5 cm above the soil. These measurements were carried out with an unsheltered thermometer but come probably near true temperatures. It is probable that in deep depressions outside the colony, considerably lower temperatures obtained on these dates.

II. WILD AND CULTIVATED HERBS

In a vegetable garden, where the earth was frozen to the depth of 2 cm, we found lettuce, peas and radishes frozen in the morning of Jan. 8 th. After sunrise they appeared again normal, in contrast to tomatoes which were injured. In an uncultivated field, nearby, we observed that many annuals, most of them in the rosette stage of early development, had frozen leaves, e.g. *Hymenocarpus circinnatus, Emex spinosus, Papaver Rhoeas, Erodium moschatum, Ajuga Iva, Paronychia argentea, Onobrychis? crista galli, Brassica Tournefortii, Calendula aegyptiaca, Onopordon* sp. The leaves of perennials, such as *Polygonum equisetifolium* and *Echium sericeum* as well as specimens of *Centaurea procurrens* surviving from last year were also frozen but were found normal after thawing (though *Polygonum* underwent defoliation in deep depressions). On Febr. 19th we noted the same resistance to freezing of their tissues in *Stellaria media, Senecio vernalis,* and the distal ends of the leaves of *Verbascum sinuatum,* though the marginal hairs of the latter were beset with ice needles up to 4 mm long.

In a flower garden we found the following herbs frozen on Jan. 8th: young seedlings of *Delphinium Ajacis,* root suckers of *Gaillardia* and weeds as *Oxalis cernua* (before flowering), *Malva parviflora, Lamium amplexicaule* and *Urtica urens.* All these except the last mentioned nettle which is rather tender, recovered completely.

In a low lying grove at Nes Ziona, we found *Urtica urens* and *U. pilulifera* damaged by frost.

Warming leaves of *Erodium moschatum* and another rosette plant, apparently *Lagoseris sancta,* by keeping them in the hand, we found their colour upon thawing darker than usual: evidently by excretion of water into the intercellular spaces.

Generally speaking, we formed the impression that the wild annuals of the *local winter vegetation* belonging to the Mediterranean, boreal or Irano-Turanian element, are well adapted by secular natural selection to freezing of their tissues. They resemble in this respect many annuals in Europe, e.g. winter cereals, cultivated *Viola tricolor, Stellaria media etc.,* which pass the winter undamaged in young stages of their development.

An entirely different situation prevailed regarding surviving specimens of the *annual summer vegetation* adapted to the conditions of the hot Oriental summer, such as *Xanthium spinosum* and *Amaranthus retroflexus.* These froze to death in low localities. The same was found true for *Solanum nigrum. Chenopodium ambrosioides,* a summer weed widespread on irrigated land, was also injured by frost. *Ricinus communis,* a species of tropical distribution, showed little frost resistance, and we are led to the conclusion that the frost affects adversely in the first line insufficiently adapted species introduced into this country at a relatively recent date.

The susceptibility of *Arisarum vulgare,* a winter perennial, to frost is in line with the succulence of its leaves and the tropical character of the *Araceae* family. Similar conditions seem to prevail among certain genera of the *Solanaceae. Lycopersicum esculentum, Capsicum annuum, Solanum nigrum* and *S. tuberosum* were found highly susceptible to the formation of ice in their tissues, while slight damage was noted in *Withania somnifera.* We saw also slight injury to leaves in *Arundo Donax,* growing in wadis, in *Cynodon dactylon* and in cultivated sugar cane. Another tender grass is the buffalo grass, *Stenotaphrum secundatum,* grown as a lawn, which turned brown even at higher evelations. *Tropaeolum majus,* often damaged by hail, was injured by the frost. Not only *Dahlia* was killed to the ground, as would be expected, but even *Chrysanthemum indicum* suffered damage in depressions.

III. ORNAMENTAL SHRUBS AND TREES

In woody ornamentals, the most conspicuous phenomenon was the killing by frost of tens of thousands of specimens of *Lantana Camara* which recently had become a pest in orchards and gardens.

Other *Lantanas* were also injured. *Bougainvillea glabra,* a climber planted everywhere on the walls of houses, was severely injured in depressions. The susceptibility to frost of these species agrees with their tropical origin. The same holds true for shrubs such as *Duranta Plumieri* (where we saw severe damage only in the variegated form) and *Dodonaea viscosa,* which was only slightly damaged.

Thevetia neriifolia, Carissa grandiflora, Caesalpinia Gilliesii, Russellia juncea were all damaged to a greater or lesser extent. They are of tropical origin. We further mention as slightly injured *Tecoma stans, Delonix regia,* and *Grevillea robusta,* while severe injury was inflicted upon *Ficus elastica* and especially *F. nitida.* At Ayanot and Beit Oved, all leaves of the latter species turned black and 1 cm thick twigs were killed. *Plumbago capensis* and *Buddleia madagascariensis* were also noted to suffer severely. At Ness Ziona and Sarafand-el-Harab we saw the Sudano-Deccanian *Lawsonia inermis* (Henna-bush) with frozen leaves, probably killed. A young specimen of *Zizyphus Spina Christi* was found seriously damaged by frost and we were informed of widespread damage on other specimens. This tree, which reaches its northern limit of distribution in Cyprus has its centre of distribution in tropical Africa. In *Acacia albida* which ecologically resembles *Zizyphus,* we saw only slight damage on few leaves, the majority of which had shed before the frost. In the West-Indian *Acacia Farnesiana,* grown everywhere as a hedge plant, the damage was at most slight, even in depressions.

Among *climbers* heavy injury was observed in *Ipomoea palmata* and *Luffa cylindrica*: their branches were killed, while native species such as *Ephedra campylopoda* remained intact. In *Peireskia aculeata,*

we saw no serious damage by light frost. Nor was there anything but slight injury on senescent leaves of deciduous climbers such as *Wisteria sinensis* and *Campsis radicans.*

Bushes penetrating into deserts are apparently well adapted to frost, e.g. *Parkinsonia aculeata* (slight injury to leaves) and *Nerium Oleander* which suffered no damage; the same holds true for many ornamentals introduced from Australia, such as *Brachychiton acerifolium* and *B. populneum* or *Eucalyptus camaldulensis* and *Callistemon sp.* which are well adapted to heat and cold. Fortunately all trees important as windbreaks, such as *Casuarina* and the various cypresses as well as *Biota orientalis,* were resistant to frost. Nor was injury observed on *Opuntia Ficus indica.* A tropical species much cultivated by the Yemenite community of Rehovot, is *Catha edulis.* In the immediate neighbourhood of a plantation of *Musa Cavendishii* killed to the ground by frost — as everywhere in depressions — this species remained intact. The same is true for *Schinus molle* reported as susceptible to heavy frost in California. *Ligustrum japonicum* was but slightly injured.

IV. CITRUS TREES AND THEIR RELATIVES

As in citrus regions of the U.S.A., damage to trees was clearly dependent upon (1) genetical properties and age of scion and stock; (2) topography; (3) care or neglect.

(1) Lemons suffered heavy damage everywhere with few exceptions, and sweet lime in nurseries was also highly susceptible to frost, much more so, than sour orange nursery stock. A Mexican Lime in a frosty locality was heavily damaged, too. Valencia and Shamouti oranges and grapefruits formed a group of medium hardiness closely followed by the hardier sour orange, while mandarins, Clementines and Marumi Kumquats were highly resistant. Sour orange stock rendered the scion more resistant than Palestinian sweet lime, but in mature trees this may have something to do with the larger size which such trees on sour orange usually attain, since, generally speaking, larger trees were less injured than small specimens. We saw little difference in susceptibility between Valencias (considered as more resistant) and Shamouti oranges, except such probably produced by age or rootstock: in one grove where fruits were frozen, the Valencias on young vigourous sour orange looked much better than low headed, old, devitalized Shamoutis on sweet lime stock. A large Pummelo tree in the collection of Mr. Holtzman at Rehovot, situated in a frosty depression showed only peripheric damage and seemed to behave as the orange-grapefruit group.

Various *Aurantioideae* planted here many years ago showed various degrees of resistance: *Eremocitrus glauca* (Australia) and *Severinia buxifolia* from China were undamaged. The tropical *Swinglea glutinosa* (Philippines) was apparently killed, being the most susceptible of the four species.

(2) Trees on the top of hills were as a rule not damaged, while such planted on slopes and in depressions suffered the more, the nearer they were situated to the bottom of an adjacent valley.

(3) Well cared for groves remained frequently undamaged while in adjacent neglected and abandoned groves under the same topographical conditions ,the trees were completely defoliated, or even killed. This was very striking and it seems that the lack of irrigation and nutrition in the abandoned Arab groves, during the preceding summer of civil war, was the main reason for a devitalization of the damaged trees weakening their power of resistance to subsequent noxious influences.

In the following summer of 1949 we were confronted with an interesting problem: how to distinguish groves heavily damaged by drought and neglect from such which had suffered from frost. It seemed that in the former case at least some peripheric branches were alive and kept their leaves, while in the latter they were all dry and consequently all young growth concentrated in the centre of the top. It seemed further that dry, frozen branches of Shamouti orange look ultimately more whitish than such killed by drought.

Damage at peripheric branches was characteristic of "isolated" trees. In dense plantations it was concentrated in the common canopy which protected lower branches from freezing.

Injured leaves of Shamouti which were not shed, showed after five weeks desiccation at their tips and less at their margins with secondary fungous infections and greasy water soaked zones transitional to the undamaged basal portion. These zones were olive-green or reddish-brown in colour.

Frozen Shamouti fruit sometimes evinced a one-sided general discoloration or spotting of the flavedo. The pulp which was not always bitter, gradually dried out and the surviving albedo was stimulated to an abnormal growth in thickness. These symptoms are well known to specialists.

V. OTHER SUBTROPICAL AND TROPICAL FRUIT TREES AND BUSHES

Widespread damage was observed in mangoes which suffered more than avocados. *Psidium Guayava* and *Ps. Cattleyanum* were defoliated by the frost. *Feijoa Sellowiana* and *Eugenia Pitanga* suffered heavy damage while *Annona Cherimola* was found more resistant. *Eriobothrya japonica* better adapted to cold in accordance with its East-Asiatic origin, remained undamaged as the olive and local blackberries which can probably resist considerably lower temperatures.

SUMMARY

The article describes the damage inflicted upon wild and cultivated herbs, vegetables, ornamentals and fruit trees by frosts of exceptional severity which occured in the coastal plain of Palestine in January and February 1949.

Fig. 1.

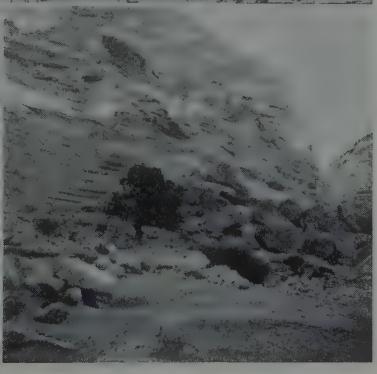
Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.



H. BOYKO — CLIMAX VEGETATION OF THE NEGEV

Fig. 7.

Fig. 8.

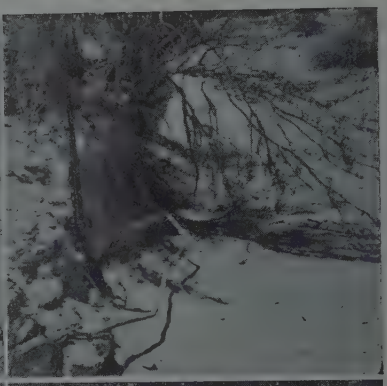


Fig. 9.

Fig. 10.

Fig. 11.

H. BOYKO — CLIMAX VEGETATION OF THE NEGEV

ON CLIMATIC EXTREMES AS DECISIVE FACTORS FOR PLANT DISTRIBUTION.

By H. BOYKO

Ecologist; Division of Research, Extension, and Agricultural Education; Ministry of Agriculture, State of Israel

I. BORDERLINES OF ANNUALS

The climatic borders of vegetation are by no means static lines. Thus the annual vegetation at the boundaries of the arid regions is particularly sensitive to the annual fluctuations of precipitation. In the early spring of 1945, for example, we found on the road from Jerusalem to Jericho, crossing the Judaean Desert, a rich vegetation of annuals on all sides of the slopes and along the whole length of the road, measuring approximately 32 kilometres. The topographical distribution of this vegetation and the composition of its societies are clearly determined by the IE-factor, i.e. they vary according to the direct sun-radiation the effectiveness of which depends in turn on the angle of inclination of the habitat for every compass-direction (2,4).

The rainfall-gradient here is exceedingly steep. The means, based on many years of observations, decrease on this short distance (23 km. only) from 500 mm in Jerusalem to 130 mm at Jericho. In normal years, starting approximately in January, a relatively rich annual vegetation may be observed along the whole length of this descent. In the spring following the very sparse winter rains of 1946/47, however, the last outposts of annual vegetation were already met with at km. 19 (counted from Jerusalem), and in order to establish the zonation according to the IE-factor, it was necessary to go back as far as km. 15, i. e. from the Saharo-Sindian deep into the Irano-Turanian territory of normal years.

Quite analogous to these conditions in the Wilderness of Judaea were those at the boundaries of the increasingly arid South of Palestine in this extremely dry year, an observation which could be confirmed on every trip to the Negev in 1947.

Most of the plains there, bare of annuals in the year 1946/47, were by no means so devoid of vegetation because of bad soil conditions; on the contrary, in years of sufficient rainfall they constitute a rich grazing ground for 4 to 5 months even in their present overgrazed state, as may be seen in the example recorded in the beginning of April 1949 and presented in table I. About half of the recorded species are annuals; the perennials, too, have benefitted from the rains and also from the interruption of grazing a year ago in consequence of the war.

conclusion that the rains, decisive for the development of the annual flora have fallen only very late in the season, in the course of the 6—8 weeks before the date of the record, viz. in February, March and in the first days of April. During this journey (early April), there were also a few violent rainshowers. Preserved specimens, of all the plants listed in the tables are kept in the Herbarium Boyko*).

Up to now no detailed plantsociological records from the Negev have been published. Therefore we insert here a few records from this botanically almost unexplored area. In these records we adhere to the principles of evaluation of Braun-Blanquet(6), noting separately degrees of a) abundance, b) dominance (coverage), and c) sociology.

We further borrow the sign + from *Braun Blanquet's* scale of "general estimate" for exact descriptions, especially in cases when they apply to quite small space units. This is done since the value 1 for abundance („very scarce, very scattered") loses its very meaning if applied to a record of small spots of therophytes as in the above example (table II.), and still more of squares embracing only a few dozens of square-centimetres as in the above quoted paper on the geo-ecological law of distribution (4).

The few facts and records given above as examples show already clearly how very decisive extreme meteorological values are for the distribution of the vegetation in time and space. According to figures received by courtesy of the Meteorological Service of Israel such extremely low rainfall-values as those recorded in 1946/47 in the Southern Desert have occurred only seven times in the course of the last hundred years, i. e. approximately once in 14 years.

Conditions of scanty rainfall up to the end of December similar to those of the winter 1946/47 occurred at Jerusalem within the period on record (from 1846/47, with the exception of 1849/50) seven times, viz:

	YEAR	mm.	
	1855/56	(34)	
	1859/60	(64)	
	1860/61	59	NOTE: Figures in brackets must
	1876/77	57	be regarded as slightly doubtful.
	1889/90	(57)	
	1933/34	40	
	1943/44	57	
as compared with	1946/47	55	

That average intervals do not mean anything in these cases is to be learned from these meteorological data. The longest interval between two years of early winter drought was 44 years (1889/90 to 1933/34). This period seems long enough to permit even woody plants, originating in less arid countries to establish themselves, provided that the other conditions are favourable.

---

*) It may be of interest to many readers that about 25,000 sheets with about 5000 species were rescued by the author from the battlefield although the house in which they were kept was badly damaged.

On the other hand records show one case when such low precipitation occurred in two consecutive years, (1859/60 and 1860/61). This may lead to the eradication of a species on a large area which will occur if not only the vegetative development but also the formation of reproductive bodies, such as seeds, must be accomplished in a shorter period, and the seeds lose their germinative capacity within one year.

As the germinative power of many species in arid climates however, lasts up to 10 or 20 years and more, the examples mentioned lead only to f l u c t u a t i o n s of the distribution limit of these species and societies and not to their extinction.

Generally speaking, records of the intensity of one factor alone rarely enable us to decide whether specific figures limiting life-processes exceed their true limiting value or not. For a satisfactory appraisal of the biological influence we must know the length of period over which this factor exerts its influence and the frequency with which it comes into play within a given period.

II. BORDERLINES OF PERENNIALS AND WOODY PLANTS

In the examples cited from the Judaean desert and the Negev we have dealt mainly with amplitudes in the distribution of *annuals*. But in the exploration of the fluctuating extension of distribution areas data regarding *perennials or woody* plants are far more important, both theoretically and practically. In the latter group the limits of distribution are not subject to fluctuations within short time-intervals as is the case with annuals. Therefore the exploration of the changing limits of distribution of perennials and woody plants requires in most cases a far longer period of observation. With respect to the time normally required for the collection of sufficient data and their interpretation, the investigation of annuals on the one hand, and that of perennials and woody plants on the other, can be compared with the relative periods required to establish facts in meteorology and climatology.

The severe drought period of 1933—40 in North America has been used by several American authors for detailed investigation into the behaviour of perennial grasses and other species composing various prairie-types. As these investigations were continued also in the following much moister years, they led to the conclusion that after a few years of recession the initial „mixed prairie" was again victorious in its fight against the intruding „shortgrass-prairies" (10). F. W. Albertson (1) published a number of highly instructive graphs and tables based on observations in a number of permanent squares which were laid out for this purpose. His data allow conclusions regarding the dependance of the quantitative development of the prairies in the Western part of Central Kansas upon the changing climatic conditions.

Now unfortunately almost no permanent squares are as yet avail-

able in the Middle East countries, and often they cannot be arranged since they would not be respected by pasturing nomads. Nevertheless an example is presented here to show how even investigations of short duration carried out after highly effective climatic events may sometimes prove helpful for the interpretation of the changing limits of distribution even of woody plants:

On the hills at the southeastern border of Jerusalem the low shrubs *Ononis antiquorum* L. var. *leiosperma* Post (= *O. leiosperma* Boiss.) and *Inula viscosa* Ait. reacted strongly to the extremely low precipitation of the winter of 1946/47 which proved hardly sufficient to cover their minimum needs during the subsequent summer.

On the hill of Givat Eliahu, 86 of the 135 specimens of the *Ononis* under observation died and even on the 49 surviving individuals two thirds of the branches were killed. But the most interesting phenomenon was the following: Whereas in normal years the various subsoils of this hill were without any obvious effect on the development of this low shrub, they proved decisive under these extreme climatic conditions. This is shown by table III.

TABLE III.

Behaviour of Ononis leiosperma Boiss. on various soils after the extremely low precipitations of the early winter 1946/47. ...

Date of record: 1. February, 1947. Site: Givat Eliahu, Jerusalem. Size of the investigated area about 200 by 200 m.

Subsoil layer	Total number of Individuals	thereof dead : alive (% in brackets)	on the surviving plants old shoots dead : alive
1) 30 cm. — 1 m. dark-brownish to grey, medium-heavy soil above several metres of deep antique rubble	23	4 19 (17 : 83)	43 32
2). On the border of an asphalt road; top soil layer as with 3). and 4).	11	3 8 (27 : 73)	24 21
3). ½ — 1½ meter of dark greyish-brown medium-heavy soil above impermeable layer of flint with clay	18	6 12 (33 : 67)	48 18
4). ½ — 1½ meter of dark greyish-brown, medium heavy soil above soft Senonian lime-stone	83	73 10 (88 : 12)	126 0

Remark: On the ten surviving shrubs 17 new shoots had appeared from the root-collar; all the old shoots had perished.

As shown in table III, this species survived best on ancient rubble, since this material seems to possess a remarkably high water retaining capacity. The relation of the dead specimens to the living ones is here 17 to 83%. The border of a metalled road proved second best, as there the moisture of the winter rains penetrating by capillary infiltration from outside is probably conserved for a relatively long time below the asphalt-cover. The relation here is 27 to 73%. (In this connection it seems interesting to note that on the road from Jerusalem to Jericho, too, the annuals advanced four more kilometres into the desert on the border of the asphalt-cover than in the surrounding stretches).

The third place is occupied by the habitat underlain by an impermeable layer of flintstones firmly cemented together by clay. Here, the number of surviving individuals, if not the number of surviving sprouts, still surpasses by far that of the dead ones, as shown by a ratio of 33 to 67%. It can be stated, therefore, that on all the formerly mentioned sites sufficient water was preserved after the rains to render the survival of the larger part of the *Ononis* plants possible.

Conditions were quite different where the top soil immediately overlays the Senonian rock, a condition typical of this and the surrounding areas. This porous soft limestone seems to drain the soil above it so much that most of the individuals perished. Thus 88% of the individuals were dead and there were only 12% cases of survival. We here find the ratio of living to dead plants to be roughly the reverse of that on the rubble of ancient buildings, and even these few survivals were due only to a few sparse young sprouts originating near the root crown while the old growth was totally destroyed by drought. It should be noted that the fourth site is inclined northwards at angles up to 15° whereas the other sites have similar inclinations but towards other directions of the compass. Thus the fourth site proved so fatal in spite of its having the lowest relative evaporation of all.

Incidentally, notwithstanding its thorny branches, this shrub is one of the most valuable fodder plants for sheep and goats on these utterly poor and overgrazed pastures.

The above example strikingly shows how, at the borders of distribution areas, otherwise negligible and indeed often neglected particulars of environmental factors gain decisive importance. At the same time such investigations lead us by a short-cut to an immediate understanding of the limits and the extension of the species studied. They may even render lengthy studies unnecessary.

Generally speaking, extreme climatic events should be exploited for extensive and varied ecological studies by as many scientists as possible at the same time, because they promise important theoretical and economic results in various directions, This applies particularly to all semi-arid and arid regions,

Analogous to the decisive rôle which the water factor plays in arid areas is that played by the factor of temperature towards the polar limits of vegetation. Interesting observations with regard to fluctuations of the border lines of tree species in such vegetation have been published by I. Hustich (7) in his studies on *Acer platanoides* L. in Far-Karelia. Here, near the Arctic circle and at the borders of forest vegetation, we find generally also a considerable parallelism between the annual fluctuations of temperature and the radial growth of trees; these phenomena have been studied extensively by Hustich (8) in Northern Finland during the last years. It is interesting to recall in this connection that E. W. Jones (9) in his comments on Hustich's results shows increment-curves from the Swiss Jura and from England, and notes that here — in these humid and temperate climates — the correlation between radial growth and temperature is also strongly influenced by the yearly fluctuations of precipitation.

III. THE INFLUENCE OF "MICRO-CONDITIONS"

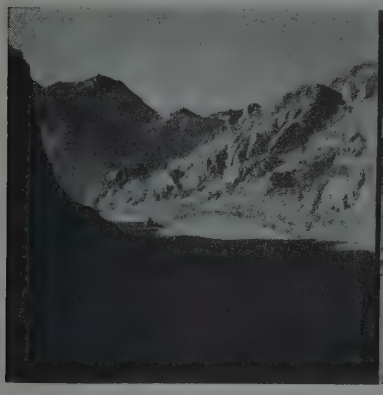
The great importance of climatic extremes coupled with the time factor lies in the fact that in general they determine the natural border lines of the large vegetational units. They are to be held responsible for the boundaries of forests towards steppes, of high-grass and mixed-grass prairies towards short-grass prairies, and, more generally, of grassland towards the scantier pastures in the half-deserts, which are usually overgrazed and composed of low desert shrubs; they also determine the natural border where life of higher plants stops altogether and the absolute desert begins.

By determining these limits through systematic studies, noting their fluctuations, and recognizing their underlying causes, we obtain indicators for lines marking originally wider distribution. These indications mark zones of potential regeneration of other plant species in anthropogenous desert areas, where ultimate success can be hoped for, which otherwise would only be expected from technical transformations i. e. mainly hydraulic projects on a large scale. The difficulties of such a regeneration on natural foundations are certainly considerable. But, though this was long a widespread belief ,it is wrong to consider the re-establishment of destroyed areas in arid regions as impossible. The fact remains, however, that a natural regeneration or re-introduction of the local vegetation meets with difficulties, which can but rarely be overcome by the accepted methods. It has too frequently been overlooked that in these border areas of plant life the *micro-conditions* are of supreme importance, and that they determine whether or not macroclimatic factors become destructive for plant life at a given locality.

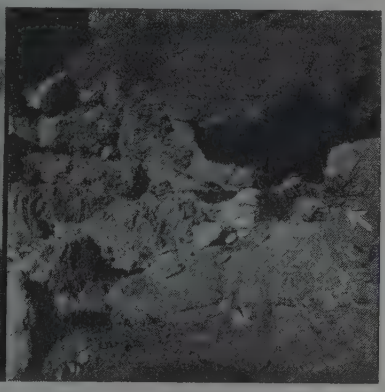
To illustrate this we have in an earlier paper drawn attention to the IE-factor [Insolation-Exposure at lower latitudes (2)]. Ever increasing observations from all over the world confirm the funda-

mental significance of this factor in the global fight of steppes against forests and of deserts against cultivated areas.

Very interesting examples of the extreme influence of exposure are to be found at Eilat (the area of Israel on the Red Sea opposite Aqaba). Here the bare granitic cliffs, covered with rubble, nearly reach the coast line (text-fig. 1). At first sight,



Text-fig. 1. — The granitic mountain desert near Eilat (Gulf of Aqaba). 1st June 1949.



Text-fig. 2. — *Anabasis articulata*, at Ras el Naq'b near Aqaba, 600 m. above sea level surviving in the wadi bed, but only hidden in the shadow of big stones.

these hills seem to be an absolute desert; but closer inspection demonstrates a considerable number of various dwarf shrubs and perennials besides isolated Acacias (*A. Raddiana* Savi and *A. spirocarpa* Hochst.). Annuals were rare. We detected only one individual of *Stipa tortilis* Def. and one of *Linaria* sp. Of course, the number of species rises with increasing height above sea level, and so does the number of individuals. According to oral reports by N. KAUFFMANN, a young botanist who, as a soldier, had the opportunity here to collect plants for several weeks, the number of species near Eilat approximates 70. The present author was able to detect more than 30 during his stay of two days on 3 and 4 April and again on 2—3 June, 1949. Both lists together constitute a list of more than 80 species.

Yet the absolute number of species matters less in connection with the problem discussed here than the analysis of the factors rendering their existence possible. It is always the coincidence of a fortuitous spread of seeds and of microclimatic or edaphic peculiarities of the habitat, which prove decisive for a plant's first establishment here. Erosion-channels offer, of course, the best prospects for the

detection of such individuals. But even in such localities pre-requisites are not only a sufficient quantity of rain, which fails in many years, but also an adequate shelter of *shade*. [Text-figs 2 and 3 and the

Text-fig. 3. — *Haloxylon salicornicum* (near the locality shown in text-fig. 2) ventures further into the sun than *Anabasis*.

plates in the paper on the climax vegetation of the Negev (5)]. The latter is a paramount requisite not only for initial development but also for the endurance of drought in the long, rainless periods of the subsequent growth. Even on Northern slopes such protection from insolation is only found amidst loose fragments of rocks or under one of the few older dwarf-shrubs, and there it is that a young plant is sometimes to be found. But here again it is usually bound to beds of water-courses originated by erosion and to the lowest parts of hills. Of course, the accumulation of fine soil particles is a further condition for the development of a plant after one of the rare showers of rain. The estimates of precipitation for Aqaba by meteorologists point to an average of only 25 mm. per annum.

Another example of the decisive importance of micro-conditions referred to in another paper (3) is offered by minor modifications in the shape of the germination-bed, such as small holes in the sands of half-deserts made by a mouse, a lizard, or even an insect, or by the stick of a beduin, where water collects after rainfalls and seeds of desert plants are enabled to sprout. Observations and experiments on these lines may play a dominant role in the reclamation of half-deserts. This is true not only for the

reclamation of arid pastures but also for plant species otherwise important as resources of mankind's economy.

On the other hand, the above example of *Ononis antiquorum* illustrates the importance of the physical properties of the subsoil and of the permeability of the underlying rock. The behaviour of this species following the extremely dry winter of 1946/47 also offers an excellent illustration of Liebig's law of the minimum in its modern application to various growth factors outside the realm of arable fields and their fertilisation. The minimum of precipitation as indicated by the rain gauge is here strongly modified by soil factors which are unimportant at higher levels of rainfall.

We are convinced that a due appreciation of the rôle played by micro-conditions in the shaping of the vegetation-cover and their detailed investigation in the border-zones of plant life is one of the main tasks of plant sociology, thus laying the foundations for a prosperous agriculture and forestry. But, at the same time, these regions are also an appropriate field for the determination of the varying ecological amplitudes and in particular of their geo-ecological shifts. The latter, in turn, are to be utilized for the establishment of quantitative climatic data determining distribution areas and their modifications by edaphic factors.

Summarizing our conclusions, we may lay down the two following rules of general applicability, the formulation of which is meant to stimulate and facilitate the work in the directions we have discussed :

1). *Near the IF-threshold of a species or society factors of otherwise subordinate significance frequently become decisive for its existence.*

The term IF-threshold denotes a line limiting plant distribution as a consequence of limiting ecological factors operating according to their intensity "I" and a time-component "F" (frequency) which often coincides with the frequency of harmful meteorological and other factors, such as heat, frost, drought, inundation, etc.

2). *As the principal factor defining the borderlines of plant distribution we should regard those climatic extremes, the "IF-value" of which just exceeds the limit of the ecological amplitude.*

The limiting IF-value embraces intensity, and a time factor which can be recurring or permanent, but must inhibit both vegetative *and* generative regeneration. If seeds or other reproductive organs, are formed, the consequences are *fluctuations* only of the border lines of the society, species or ecotype in question. Such fluctuations can, of course, be either annual, perennial or secular, according to the occurrence in time of the climatic extremes inducing them. The exact mathematical definition of the IF-value will form the object of further studies.

SUMMARY

1) It is shown that the distribution areas of annuals in arid regions fluctuate considerably in dependance upon precipitation. This is substantiated by examples from the Judean desert and the desertic Southern district of Israel (Negev). Added are plant-sociological tables containing quantitative data on the number and size of individuals in the squares.
2) The influence of extreme meteorological phenomena on the distribution of perennials and woody species is discussed.
3) It is shown that even the fluctuation of distribution areas of woody species can be studied by rapid investigation methods Local factors, unimportant under less extreme conditions become decisive for forestry and range management in the border areas of plant-life. This is illustrated by some typical examples, as the behaviour of *Ononis leiosperma* at a locality near Jerusalem.
4) Not only the *intensity* of extreme climatic factors, but also the *frequency* of their occurrence proves important in the interpretation of the fluctuations discussed in the article.
5) The conceptions "IF-threshold" and "IF-factor" are defined.

REFERENCES

1. Albertson, F. W. (1939—1945). Prairie studies in west central Kansas. Transactions Kansas Academy of Science, 42:97—107 (1939); 44:48—57 (1941); 45:47—54 (1942); 46:81—84 (1943); 47:405—414 (1945).
2. Boyko, H. (1945). On Forest Types of the Semi-arid Areas at Lower Latitudes. *Pal. Journ. of Botany*, Reh. Ser. 5:1—21.
3. Boyko, H. (1946). Report on arid pasture investigations, executed in Tureibe range East of Kurnub. (distributed as Ms.). *Govt. of Palestine.*
4. Boyko, H. (1947). On the Role of Plants as Quantitative Climate Indicators, and the Geo-ecological Law of Distribution. *Journ. of Ecology* 35/1—2:138—157.
5. Boyko, H. (1949). On the climax Vegetation of the Negev (with special reference to arid pasture problems). *Pal. Journ. of Botany, Reh. Ser.* 7:17—33.
6. Braun-Blanquet, J. (1932). Plantsociology. Transl. G. D. Fuller and H. S. Conard., 1932.
7. Hustich, I. (1945). Ueber die Nordgrenze des Ahorns (Acer platanoides L.) in Fern-Karelien. *Mem. Soc. Fauna et Flora Fennica* 20:95—104, Helsinki.
8. Hustich, I. (1948). The Scotch Pine in Northernmost Finland and its Dependence on the Climate in the last Decades. *Acta Bot. Fenn.* 42:1—75, Helsinki.
9. Jones, E. W. (1947) Remarks on "Climatic fluctuations and vegetation growth in Northern Finland during 1890—1939" by I. Hustich. *Nature*, 160:478.
10. Weaver, J. E., & Albertson, F. W. (1944). Nature and Degree of Recovery of Grassland from the Great Drought of 1933 to 1940. *Ecol. Mon.* 14:393—479.

STUDIES OF THE PHENOLOGY OF SOME WHEAT VARIETIES IN PALESTINE

By DANIEL SIEV (WEISS)
(Agricultural Experimental Council of the Jewish Settlements in the Jordan Valley, Daganiah B)

A. INTRODUCTION

For centuries local wheat varieties belonging to the species *Triticum durum* used to be sown in Palestine. Two of the most important ones are the varieties "Nursi" and "Etti". During the last years new wheat varieties were introduced into Palestine which rendered good economical results. Three early varieties "B.I.P.M.", "C.C.C."and "Florence" are usually grown. All three belong to *Triticum vulgare*. All wheat varieties sown in Palestine are spring wheats in accordance with climatic conditions obtaining in this country.

"Winter wheat" in the countries where it is grown, undergoes an interruption of growth activity during the winter. During this period the plants are in the tillering stage and have not yet entered the shooting stage. Winter wheat performs shooting and heading in days which are longer than twelve hours and lengthening further, as is the case in spring.

"Spring wheat" sown in spring in countries where winter is cold, grows from germination until heading generally in days longer than twelve hours and lengthening in succession. Winter wheat that has undergone vernalisation behaves the same way.

In Palestine wheat usually germinates in November or later according to the beginning of the rainy season. It undergoes tillering partly in the period of shortening days, partly in that of lengthening days. Days in both periods, however, are shorter than twelve hours. It passes through shooting in the period of lengthening days and reaches heading in days shorter or longer than twelve hours, according to variety. In the following table we quote the dates of heading of five wheat varieties in Palestine from the paper of AHARONOVITCH and KOSTRINSKY (1).

TABLE I.

Heading Dates of five Wheat Varieties in Palestine

Variety	*Heading of early sown wheat* (3-14.XII)	*Heading of late sown wheat* (4-31.I)
B.I.P.M.	25.II	16.III
C.C.C.	1.III	7.IV
Florence	9.III	12.IV
Etti	7.IV	17.IV
Nursi	7.IV	17.IV

According to LYSENKO (4) wheat (and other annual plants) undergo developmental stages, succeeding one another, and a later stage of development cannot take place unless the former one has been completed.

An early development stage is the thermostage. During this stage, wheat needs low temperatures. For spring wheat temperatures from +5° to +20° are stated (LYSENKO, as above). A later development stage is the photo-stage. During this period, wheat is supposed to need a day longer than twelve hours. The last developmental stage is the flowering of the plant.

Among the above varieties, the variety B.I.P.M. is distinguished by its early heading. For this variety arises the problem of its photo-periodic reaction on a long day. During the seasons 1945-46 and 1946-47, I made observations on the above wheat varieties in plots specially sown for this purpose. The results of these observations add weight to this problem and raise others.

B. OBSERVATIONS.

In the season of 1946-47 small plots of the above five varieties were sown at Daganiah with intervals of about one month. The varieties, the dates of germination and the length of the period from germination to heading are presented in Table II.

TABLE II.

Dates of Germination and Heading and Number of Interval-Days of five Wheat Varieties

	B. I. P. M.			C. C. C.		Florence		Etti		Nursi	
Plot	Date of germination	Date of heading	Days from germination to heading	Date of heading	Days from germination to heading	Date of heading	Days from germination to heading	Date of heading	Days from germination to heading	Date of heading	Days from germination to heading
A	10.IX.46	8.X.	28	28.X.	48	— —	—	19-30.I	131-142	13.III.	18
B	28.IX.46	31.X.	33	—	—	— —	—	—	—	13.III.	16
C	2.XI.46	13.XII.	41	—	—	13-22.I	72-81	15.II.	105	13.III.	13
D	7.XII.46	8.II.	63	—	—	27.II-2.III	82-85	10.III.	85	23.III.	10
E	13.I.47	8.III.	54	—	—	24.III	70	—	—	5.IV.	8
F	13.II.47	30.III.	45	—	—	7.IV	53	—	—	16.IV.	6
G	4.III.47	11.IV.	38	—	—	21.IV	48	29.IV.	56	3.V.	6

Germination took place 5-7 days after sowing.

According to this table two types can be distinguished among these varieties according to the length of the period from germination to heading.

A. An early type (of introduced soft wheats) for which the variety "B.I.P.M." can serve as an example. In early sowing the length of the period from germination to heading of this variety was twenty-eight days. The number of days from germination to heading increased until the sowing on Dec. 7, (Plot D) and reached 63 days. Afterwards the length of the period till heading decreased

again. The "C.C.C." variety apparently also belongs to this type. In early sowing (season of 1946-1947) it headed after 48 days from germination. In the 1945-1946 season this variety headed after 80 days from germination, after it had been sown on Dec. 14, (the same as in table I). It headed after 61 days when sown late, on Febr., 9.

The "Florence" variety also shows the same tendency (table II).

B. A late type of (hard) wheat for which the variety "Nursi" can serve as example. The number of days from germination to heading is great in early sowing, and the longer sowing is delayed the more it decreases; in the "Nursi" variety the number of days started with 184 and decreased to 60; in the "Etti" variety it started with 131—142 and decreased to 56.

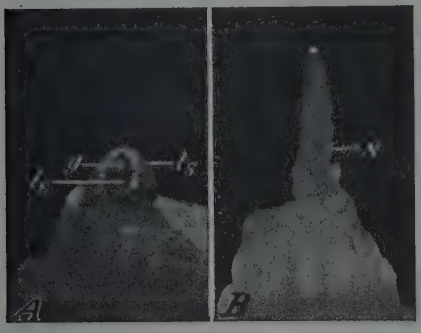


Figure 1. A. Vegetative growing point of wheat. g=growing point. l_5 and l_6 = initials of the fifth and sixth leaves.

B. Reproductive growing point of wheat. x=upper portion of double ridges initiating the formation of a spikelet. (After *Bonnett* (1936).

In order to find out when the transition from the vegetative to the reproductive stage takes place in these varieties, the growing points of the plants were examined by means of a microscope. The examination was made of the first stem only of the plant. The stage of the development of the growing point was determined in comparison with the photo-micrographs of Bonnett (3; Plate I). In the following we are using his designations:

a and b = aspects of the vegetative stage of the growing point.
c = transition to the reproductive stage.
d = beginning of the differentiation of the spikelet.
e = early stage of the spikelet formation.
f = a spikelet before the differentiation of its parts.
g = beginning of differentiation of the glumes.
h = well-differentiated glumes.
i = beginning of further differentiation.

In the vegetative stage (a and b) every ridge beneath the apex of the growing point is a leaf initial. The reproductive stage begins with d; the criterion of its beginning: double ridges beneath the apex of the growing point. The upper part of the double ridge is the initial of a spikelet.

TABLE III.

Developmental stages of the growing point dependent upon different sowing times.

		B. I. P. M.		C. C. C.		Florence		E t t i		N u r s i	
Plot	Date of germ.	Stage	Days from germ.	Stage	Days from germ.	Stage	Days from germ.	Stage	Days from germ.	Stage	Days from germ.
A	10.IX.	g	11	e	26	—	—	d	40	—	—
B	28.IX.	g-h	11	—	—	—	—	—	—	d	41
C	2.XI.	h-i	20	—	—	e	20	d-e	35	c-d	35
D	7.XII.	d-e	14	—	—	e	27	—	—	—	—
E	13.I.	—	—	—	—	—	—	—	—	—	—
F	13.II.	e	14	—	—	d-e	19	f	30	g	30
G	4.III.	f-g	15	—	—	c-d	15	d	32	f-g	32

Unfortunately I could not make the examinations at close intervals, and, therefore, the description of the development of the growing point is not complete. Furthermore, I did not succeed in determining the beginning of every respective stage in accordance with the time of sowing. Nevertheless we can draw the following conclusions from this table:

a) The growing points of the early variety B.I.P.M. pass to the reproductive stage earlier than those of the "Florence" variety, and the latter earlier than those of "Etti" and "Nursi".

b) The approximate number of days from the transition to the reproductive stage till heading was small in the variety B.I.P.M. in early sowing, increased continuously to sowing of plot D, and again decreased continuously in later sowings in the following order: In sowing of plot A the number was about 19; in sowing of plot D — 49; in sowing of plot G — 23. In the "Nursi" variety this number was large in early sowing and decreased the more the sowing was delayed. In plot B it was 125 days, in G — 28 days.

As to the changes in the length of the *period from germination to the transition to the reproductive stage* according to sowing time and variety, it seems that they have the same trend as the number of days from germination to heading. The data, however, are not sufficient to state this definitely.

While the first stem had already developed a reproductive growing point, new tillers appeared in all varieties, each with vegetative growing points. "Etti" had three tillers at the time when the first stem had a reproductive growing point. At the time of heading it had 14 stems. With "Nursi" the phenomenon was even more pronounced. Spring wheat sown in Palestine at the beginning of winter differs in this respect from winter wheat in its home-zones. For in our spring wheat we find vegetative and reproductive growing points at the same time co-existing during a long period. As to spring wheat sown in spring in cool environment, I did not find sufficient data.

In the late sowings in plots D, E, F, G (part of them still sown at the usual season in Palestine) coincidence of the process of tillering and shooting was noted. Reaching shooting stage, all ceased tillering, grew up simultaneously, and then headed. The only difference was that in the early varieties the whole process required less time.

In the early sown plots A, B, C, however, this process took place in a different order with both groups of wheat. In the late varieties "Etti" and "Nursi" the plants passed simultaneously to shooting, developed the full number of leaves till heading, and remained a long time in a state where the spike is ready to emerge from the sheath of the upper leaf, but the spike did not appear. After a considerable delay they headed. In the "Nursi" variety this delay lasted for over 5 weeks.

A remarkable phenomenon deserving emphasis was noticed in the spikes of the "Nursi" variety in plots A and B, which showed a considerable delay in the emergence of the spikes. Usually one finds a small rudiment of a leaf in the shape of a little belt surrounding the stalk beneath the lowest spikelet of every wheat spike. The length of this rudiment in the spikes of the "Nursi" variety sown in plots C and D (i.e. at the sowing time customary in Palestine), was measured. It was one millimeter long on an average. But if there was a delay in the emergence of the spike (plots A and B), we noticed a leaflet of not inconsiderable length at this place. The length of this leaflet was 7.4 millimeters on an average of 10 spikes (see figure 2).

Figure 2. *Left.* Spike of the wheat variety Nursi which emerged from the stem without delay. Note rudimental bract beneath the lowest spikelet. Its length is about 1 m/m. *Right.* Spike of the same variety emerging after prolonged delay. Beneath the lowest spikelet a well formed bracteal leaf, 10.5 m/m. long (ca. 1/1).

A quite different course of development took place in the early varieties "B.I.P.M." and "C.C.C." grown on plots A and B. The first tillers headed rather early (table II). They had already mature spikes in a season when normally tillering occurs in Palestine. But they continued to tiller also after heading. A new series of tillers again reached heading (while the season of tillering had not yet passed). The plants continued to tiller also after the second heading, and a third series of spikes appeared. Tillering continued and a fourth series of spikes appeared. The different series of spikes were not quite distinct, but most spikes of each series matured together (fig. 3).

Figure 3. *Right:* Wheat plant of the B.I.P.M. variety, 91 days old. *Left:* Wheat plant of the C.C.C. variety, 109 days old. In both the haulms (1) the ears of which have been removed, belong to the first series of heading stems. They were cut on Nov. 10. The other ears still present (2) belong to a second series. A third series of tillers (3) is seen emerging from the base of both plants.

TABLE IV

Number of spikes and of non-headed tillers per plant at different dates.

Variety	Date of germination	Date of observation	Average number of spikes	Average number of yet non-earing tillers
B.I.P.M.	10.IX	16.X	1.9	1.0
		8.XI	5.0	3.0
		22.XII	10.0	1.6
		21.II	13.1	0.5
C.C.C.	10.IX	8.XI	3.8	3.4
		26.XII	14.2	2.7
		21.II	17.5	0.2
B.I.P.M.	28.IX	8.XI	5.0	1.9
		26.XII	12.7	3.7
		21.II	24.0	1.3

Part of the plants of the "B.I.P.M." variety were placed in darkening boxes every day from noon onwards, with the purpose of shortening the length of day. The period of darkening lasted from November, 25 to February, 1. The darkening plants continued tillering and, at the same time, heading.

In the 1945-46 season the plots were sown at later dates than in the season of 1946-47. The germination in the first plot took place on December, 9, and that in the last on February, 9. Therefore only part of the observations during the two seasons can be compared. In the comparable part the data of 1945-46 conform to those of 1946-47.

In both seasons the *number of leaves* on each stem was counted. After heading, 50 stems of each variety from each sowing date were collected at random, and the leaves were counted. In both seasons it was found that the earlier the tested variety was, the less leaves it bore. In the season of 1946-47 the average number of leaves for each stem of plots C, D, E, F was as follows: Variety "B.I.P.M." — 4.6; "Florence"—5.7; "Etti"—6.9; "Nursi"—7.8 (significant difference= 0.7 for p=0.01).

C. DISCUSSION

From the above phenological observations on some varieties of wheat in Palestine, some prominent facts come forth:

A. The early varieties reached full heading at relatively very high temperature. The varieties "B.I.P.M." and "C.C.C." passed the time from germination to the formation of the reproductive growing point and beginning of shooting in an average temperature of 29.7°C. Since this temperature approaches the maximum of the average monthly temperature throughout the year of so warm a region as the Jordan Valley, it is doubtful whether regarding these varieties one can speak of any need whatever for a "thermo-stage". With regard to them such a stage cannot be recognised at all.

B. The early varieties reached heading in days shorter than twelve hours. What was sown early, headed before the 22nd December, i.e. during continuously shortening days, and the part sown later headed during lengthening days. Therefore the early varieties cannot be included in the plants of the long day and their heading cannot be said to depend on a photo-stage, defined according to the ratio between length of day and night.

As to the late varieties "Etti" and "Nursi" we ascertained that the development of their reproductive growing point takes place in the early sown plots A, B and C, also in the season in which day length was on the decrease and shorter than 12 hours. The obvious delay between the end of the shooting stage and the emergence of the spike is apparently due to the fact that the photo-stage is composed of several secondary developmental phases each one requiring its specific ratio between light and darkness.

C. Comparing the length of the period between germination and heading of variety "B.I.P.M." as sown in autumn and in spring, we choose only the seasons when day length was nearly equal. Of course, in the autumn days form a succession from long to short while the corresponding days in spring change from short to long. Only the sum of light hours of both seasons will be compared.

TABLE V.

Number of days from germination to heading and day-length in different sowing seasons (B.I.P.M. variety).

Sowing before 22nd December							Sowing after 22nd December						
Plot	Days from germination to heading	The shortest day between germination and heading			The longest day between germination and heading			Plot	Days from germination to heading	The shortest day between germination and heading			The longest day between germination and heading		
		Date	h.	m.	Date	h.	m.			Date	h.	m.	Date	h.	m.
A	28	8.X.	11	38	10.IX.	12	34	G	38	4.III	11	31	11.IV.	12	50
B	33	31.X.	10	55	28.IX.	11	58	F	45	13.II	10	58	30.III.	12	28
C	41	13.XII.	10	01	2.XI.	10	51	E	54	13.I	10	11	8.III.	11	41

Day -length from sunrise to sunset has been calculated for the latitude of Daganiah according to the Nautical Almanac for 1946.

In plot D the wheat variety "B.I.P.M." germinated on Dec. 7, with a day length of ten hours and five minutes. Till Dec. 22nd days shortened by a few minutes only. When this wheat came into ear on Febr. 8, day length was 10h. 48m.

According to this table, a larger number of light hours to evoke heading was needed by plants of plot G than by those of plot A, though the shortest day of their growing seasons was nearly equal. Correspondingly, for sowing F a greater number of light hours was needed than for sowing B, and for sowing E — more than for sowing C, though the shortest days of F and E were longer than the corresponding shortest days of B and C. We may conclude that the heading of the "B.I.P.M." variety required a larger number of light hours in the period of lengthening days and a smaller one in the period of shortening days.

D. All the varieties continued forming vegetative tillers, while part of their tillers had already a reproductive growing point. The early varieties continued tillering long after heading, and even after part of their grains had matured. According to LYSENKO (4) the developmental stages of annual plants succeed one another, and a later stage of development cannot take place before the former one has been completed. The last stage is flowering. In our observations this rule was only verified with regard to each separate tiller. Each tiller taken alone underwent the developmental stages successively. The plant

as a whole, however, after reaching the terminal stage of flowering and maturing, went through the previous stage of vegetative tillering again and again. Under field conditions, wheat after heading ceases developing vegetative tillers and thus ends its life as an individuum. What is the reason for this? In Palestine there is a decisive reason: the pronounced drought of summer. In most wheat growing countries (also in Palestine on irrigated land) heading takes place in a season of long or very long days and it can be surmised, that these long days are not suitable for tillering, and consequently such wheat ends its life. According to our observations, however, wheat tillered in every case when days were short, no matter if before heading or after it.

When long days follow short ones, the order of stages as stated by LYSENKO is correct. When, however, the order was reversed, i.e. when after long days followed short ones (and at the same time growing conditions were suitable), the vegetativeness was evidently the immediate result of the influence of external conditions, but not of the inherent order of successive stages.

In analogy to the above wheat varieties, at least one other annual field crop can be indicated that develops vegetative growth even after flowering. *Trifolium alexandrinum* grown in Palestine for forage, does not blossom during all the winter and develops stems and leaves only. Its life ceases with the onset of summer and heat, after having blossomed. In early sowing in the Jordan Valley it happens, however, that it blossoms already in autumn. After this it continues growing without flower formation during all the winter, for winter conditions favour in this plant vegetative growth only. With the beginning of the warm season it blossoms again.

E. The appearance of the leaflet beneath the first spikelet of the "Nursi" variety of plots A and B is apparently due to delay in the emergence of the spike. We have already mentioned the double ridges of the growing point, characteristic of the beginning of the reproductive stage (page 55). According to PURVIS (5), the upper part of such a ridge develops into a spikelet, and then the lower part, being the initial of the leaf, is checked in its growth and immerges in the corresponding internode. If, however, there are no suitable conditions for reproductive development of the apex, a leaf will develop from the lower part of the double ridges whereas the upper part will not develop. In early sowings of the "Nursi" variety (plots A and B) a considerable delay in the emergence of the spike, i.e. in the reproductive development, takes place, and consequently the leaflet beneath the spike is developed.

F. The facts that the different varieties produce different numbers of leaves, that they are early or late in the formation of the reproductive growing point, and enjoy a longer or a shorter period of tillering, are of practical importance. Indeed, they can be considered fundamental for the adaptation of varieties to a certain environment in agricultural practice and in particular for the choice of the proper

cultural settlers of Palestine and the results of our observations may prove helpful for their solution.

D. SUMMARY.

A. Data regarding length of the period from germination to heading of five varieties of wheat in Palestine sown at different dates, have been collected.

B. The time of transition of the growing point to the reproductive phase has been fixed approximately. As expected, the transition takes place earlier in the early varieties and later in the later ones.

C. After transition to reproductive growth in the first stem, vegetative tillers continue to develop in all varieties and at all sowing times. Tillers continue to appear in the early varieties, even after heading. Thus several series of heading stems develop.

D. At least the early varieties passed through their early developmental stages until shooting (and even until heading) at very high temperatures. Therefore it is doubtful whether an obligatory cool thermo-stage can be attributed to them.

E. The early varieties headed in days shorter than 12 hours. With early sowing dates day-lengths were gradually shortening from germination to heading.

F. The sum of light-hours as well as day-length, conducive to heading of the variety "B.I.P.M." was smaller in the period of shortening days (autumn) than in the period of lengthening days (spring).

G. The results strongly suggest that the ratio between durations of day and night is not the only factor causing heading.

I. The early varieties resume tillering during a long period after their first heading. This upsets the order postulated by LYSENKO as obligatory for annual plants, namely that developmental stages succeed one another according to a fixed predetermined scheme from germination to flower production.

J. The number of leaves of every stem was the higher the later was the tested variety.

K. In the "Nursi" variety a leaflet appeared beneath the first spikelet in those spikes whose heading was delayed.

REFERENCES.

1. AHARONOVITCH, I. & KOSTRINSKY, I. (1940-42). Experiments with winter wheat varieties. Hassadeh Library. Tel-Aviv (Hebrew).
2. ALLARD, H. A. & GARNER, W. W. (1940). Further observations on the response of various species of plants to length of day. *U. S. Dept. Agr. Techn. Bull. No. 727.*
3. BONNETT, O. T. (1936). The development of the wheat spike. *J. Agr. Res.* 53, No. 6.
4. LYSENKO, T. D. (1935). The theoretical foundations of vernalisation. *State Publishing Office (Gosizdat)*, Moscow (Russian).
5. PURVIS, O. N. (1934). An analysis of the influence of temperature during germination on the subsequent development of certain winter cereals and its relation to length of day. *Ann. Bot.* 48:919.
6. PURVIS, O. N. & GREGORY, F. G. (1937). Studies in vernalisation of cereals. Part. I. *Ann. Bot. N. S.* 1:569—592.

LA DETERMINATION DE L'OUVERTURE STOMATIQUE CHEZ LA TOMATE

PAR H. R. OPPENHEIMER
Département de la Culture des Agrumes et Botanique Agraire
Station de Recherches Agronomiques, Rehovot

I. BUT DES RECHERCHES

On sait qu'aucune des méthodes développées pour la mesure des ouvertures des stomates n'est applicable à toutes les espèces des plantes. C'est pourquoi le physiologue est obligé de choisir la méthode la plus exacte et la plus convenable à cet effet, dans tous les cas où il étudie l'échange gazeux des feuilles réglé par les stomates.

En 1939, notre département se trouvait devant la nécessité d'étudier les facteurs qui empêchaient la réussite des pépinières de tomates semées en pleine été dans la Vallée du Jordain, au sud du Lac de Tiberiade. Les études météorologiques et physiologiques de MENDEL qui n'ont pas encore été publiées, ont cependant confirmé notre supposition que c'est la température estivale trop élevée de cette région qui ne permet pas l'assimilation normale d'anhydride carbonique. Mais il paraissait d'abord nécessaire de baser ces études écologiques sur une fondation méthodique solide; aussi avons-nous entrepris l'élaboration d'une méthode sûre pour la mesure des stomates de cette espèce.

II. METHODES PEU APPROPRIEES

Tout d'abord, on a essayé la méthode d'infiltration de Molisch qui nous a rendu de bons services dans de nombreuses autres espèces de plantes et qui offre l'avantage de rendre superflu l'usage du microscope. Mais bientôt nous nous sommes convaincus que cette méthode ne convient pas à la tomate. D'abord la chevelure de l'épiderme gêne l'observation; mais le plus grave c'est que des liquides comme le xylol, le pétrole, etc. dont on s'est servi, s'étalent très rapidement dans le parenchyme spongieux après leur pénétration à l'intérieur des feuilles. Cette circonstance ne permet pas à l'observateur de se rendre compte si le liquide a pénétré par de nombreux stomates ou bien par quelques-uns seulement dont l'ouverture n'est pas typique pour la feuille à l'état étudié. Toutefois, on peut vérifier, à l'aide de cette méthode, si les stomates sont peu ou largement ouverts. Dans le premier cas, le xylol et le pétrole pénètrent immédiatement, mais un mélange d'huile de térébenthe en proportion de 1 sur 2 ou l'huile de paraffine ne provoquent pas, ou très peu, l'infiltration. Or, ces derniers liquides pénètrent par les ouvertures stomatiques si l'ouverture est plus large, c.à.d. à peu près 2 microns ou davantage.

L'observation directe des stomates dans les feuilles vivantes de la tomate a été pratiquée avec succès par MITCHELL (1) et par WENT (4). Le premier de ces auteurs indique que les ouvertures ne changent pas, ou changent peu, si l'on fait les observations dans les trois minutes après le changement des conditions auxquelles les feuilles étaient soumises auparavant. Cependant, il n'indique pas s'il a exécuté ses observations sur feuilles détachées ou non. WENT ayant observé que les stomates se ferment au cours de quelques minutes, si les feuilles sont arrachées de la plante, a fait ses observations sur feuilles intactes attachées à la plante. Pendant le mesurage, leur surface fut illuminée artificiellement par-dessus à l'aide d'une lampe "Ultropak". Evidemment ces méthodes sont peu appropriées aux besoins d'écologues qui désirent étudier, dans la campagne, le comportement physiologique de l'objet.

III. METHODE DE FIXATION

C'est pourquoi on a essayé d'établir si la fixation de l'épiderme par des *liquides déshydratants* rend des résultats corrects dans le cas de la tomate. NADEL (2) avait démontré, dans notre laboratoire, que la méthode de fixation de LLOYD — qui se sert à cet effet de l'alcool absolu — rend souvent d'assez bons résultats, à condition que l'épiderme ne soit pas adhérent au parenchyme spongieux. Dans ce cas, l'épiderme est facilement détachable. Parmi les objets étudiés par NADEL se trouvaient, entre autres, le *Solanum nigrum*, à épiderme assez lâchement uni avec le mésophylle. Chez cette espèce, les stomates d'épidermes détachés et plongés dans l'alcool ne se rétrécissaient que peu par comparaison avec ceux mesurés dans des feuilles intactes.

On a constaté aisément que l'épiderme des feuilles de tomates est aussi facilement détachable. Cette circonstance semblait hausser les chances de succès. Cependant, par comparaison de la largeur des ouvertures *in vivo* et dans l'épiderme isolé et plongé dans l'alcool, nous nous sommes convaincus que l'alcool produit un *rétrécissement considérable* des ouvertures, comme NADEL l'avait établi dans de nombreuses espèces.

En comparant les ouvertures, on s'est servi de l'illuminateur "Opak" pour l'observation *in vivo*, et l'on a pu se convaincre que l'éclairage des feuilles ou de parties de feuilles par-dessus facilite de beaucoup le mesurage exact de la largeur des ouvertures stomatiques. Par journées normales d'été, avec humidité relative de 70 ou 80% dans l'avant-midi, nous avons constaté que l'ouverture ne change pas beaucoup pendant un quart d'heure ou même une demi-heure dans des folioles détachées qui se trouvent au laboratoire sous l'objectif du microscope. Par contre, on n'a pas pu faire de comparaisons par des journées de sirocco quand le degré de saturation de l'atmosphère descendait jusqu'à 15% et les stomates étaient fermés, ou presque, pendant toute la journée.

Le 26 Juin 1939, étant un jour d'été propice, nous avons mesuré l'ouverture des stomates dans une partie de foliole vivante observée à l'aide de l'„Opak" et, par comparaison, dans un morceau d'épiderme voisin, tiré du même foliole et plongé immédiatement dans l'alcool. Dans le fragment de feuille, l'ouverture moyenne de dix stomates était de 3.8 ± 0.16 microns. Par contre dans l'alcool, les stomates étaient fermés en beaucoup d'endroits examinés, tandis que dans un autre endroit, dix stomates avaient une ouverture de 4.1 ± 0.15 microns, c.à.d. tout à fait semblable à l'état naturel.

Dans une deuxième série de mesures, on a observé une partie de feuille d'abord *in vivo,* marquant à l'encre de Chine l'endroit où les stomates furent mesurés. Puis l'épiderme *du même endroit* fut enlevé, transféré dans l'alcool et le mesurage répété. La largeur des ouvertures variait entre 0.5 et 5.0 microns in vivo, et entre 0.5 et 2.6 microns dans l'alcool. Les moyennes étaient respectivement de 2.9 et 1.5 microns. Les stomates s'étaient donc rétrécis considérablement, sous l'influence de l'alcool. Vers le soir, on trouva, dans une troisième série de mesures une moyenne de 3.3 microns *in vivo,* tandis que dans l'alcool, les stomates étaient fermés, ou presque fermés. Dans cette série les résultats dans l'alcool étaient donc de nature à égarer l'observateur. Etant donné les résultats défavorables de ces examens, on a décidé d'essayer le *dioxane* au lieu de l'alcool pour la fixation des stomates dans l'état naturel. Ce liquide, dont l'usage à cet effet a été proposé d'abord par Nadel (2) mais n'a pas trouvé auprès des observateurs i'intérêt qu'il mérite, lui a rendu d'excellents services dans le *Vinca rosea, Medicago sativa, Plantago Lagopus,* etc.

Le 29 Juin, on trouva à 8.20 du matin, les stomates peu ouverts quand on en mesura dix dans une partie de feuille dans leur état naturel. Après désignation de l'endroit aux stomates mesurés à l'encre de Chine on a rapidement enlevé l'épiderme, en le coupant tout de suite en deux, à l'aide d'un rasoir, en l'endroit marqué. Une moitié fut transférée dans l'alcool absolu, l'autre dans le dioxane. Toute cette opération s'accomplit en quelque secondes. Mesurant dix stomates dans chacune des petites parties d'épiderme, on a obtenu les résultats suivants :

Ouverture moyenne dans l'état naturel (un stomate fermé)	1.35	microns
„ „ dans l'alcool (quatre stomates fermés)	0.59	„
„ „ dans le dioxane (pas de stomates fermés)	1.85	„

Une fois de plus on eut donc l'impression que l'alcool rend les ouvertures trop étroites, tandis que dans le dioxane elles se rapprochent davantage de leur état naturel.

Cependant, le petit degré d'ouverture dans l'état naturel représentait une condition défavorable pour l'obtention de différences bien prononcées.

A 10 heures 40, l'ouverture large des stomates présentait des conditions excellentes pour une expérience décisive, exécutée de la même façon que la précédente. On établit en moyenne les ouvertures suivantes :

État naturel :	
(à sec, éclairage d'„Opak" par-dessus)	4.3 microns
dans l'alcool	1.9 „
dans le dioxane	4.4 „

Cette fois, l'ouverture dans le dioxane correspondit donc très bien à l'état naturel. Par contre, l'alcool avait rétréci les ouvertures à plus que 50%. Dans ce liquide, deux stomates sur dix apparaissaient fermés, contrairement à ce que l'on observait à l'état naturel et dans le dioxane.

Vers le coucher du soleil, à 18 h. 40, on trouva une ouverture moyenne de 1.5 microns à l'état naturel. Une autre feuille, dont l'épiderme fut examiné dans le dioxane, rendit exactement le même résultat.

La marche diurne des mouvements stomatiques de ce jour comme d'autres, correspond bien aux résultats de Went (4) obtenus en Californie.

Nous aussi pouvons confirmer qu'en général, l'état d'ouverture des stomates voisins n'est pas du tout uniforme. Il va sans dire que cette circonstance diminue la valeur d'indications concernant une ouverture moyenne typique.

IV. EXAMENS PHYSIOLOGIQUES PRELIMINAIRES

Après avoir établi que la fixation de l'épiderme par le dioxane représente une méthode convenante au mesurage stomatique de la tomate, on a essayé de s'en servir pour établir la marche diurne de l'ouverture dans des plants poussant en pots. Ces derniers furent placés en serre ou à l'air libre, soit en plein soleil, soit dans l'ombre. Plusieurs fois par jour on en a arraché des feuilles pour examiner l'accumulation d'amidon, en se servant de la méthode classique de Sachs (3). Les feuilles d'une partie des plants furents arrosées pendant les heures les plus chaudes; d'autres ne le furent pas.

Comme résultat de ces recherches préliminaires, on a établi ce qui suit :

(1) L'ouverture des stomates pendant la journée du 4 Juillet 1939 (jour d'été normal) fluctuait en général entre 1.5 et 3.7 microns. L'ouverture maximale était de 5.6 microns et il y avait toujours de grandes différences entre stomates voisins.

(2) A 9 heures et à midi, l'ouverture moyenne était beaucoup plus large chez les plants placés à l'ombre que chez ceux qui se trouvaient en plein soleil.

(3) L'arrosage des feuilles produisit dans l'un des cas des ouvertures plus grandes (à midi, en serre) tandis que dans un autre

cas (à midi, en plein soleil) on trouva les stomates des plants arrosés fermés ou presque, en contraste aux témoins non arrosés, qui avaient des stomates ouverts.

(4) Vers le soir, les stomates se rétrécirent considérablement.

L'assimilation chlorophyllienne conduisit déjà jusqu'à midi à un noircissement considérable des feuilles traitées par l'iode, qui, dans l'échelle de Sachs, correspond aux degrés 3 à 4.

Cependant on ne put établir à cet égard des différences bien marquées entre exemplaires placés au soleil, à l'ombre ou en serre. De même l'arrosage des feuilles destiné à les rafraîchir, n'exerça pas une influence prononcée. L'activité assimilatrice prononcée des plants non arrosés indiquait que dans les conditions de la journée en question, l'arrosage était superflu.

Le 28 et le 29 Juin aussi on a trouvé beaucoup d'amidon quoique ce fussent des jours très chauds. Par contre le 2 et le 3 Juillet l'assimilation chlorophyllienne était très défectueuse, à en juger par l'épreuve de l'amidon. Il nous est impossible d'en indiquer la raison, mais il nous semble que les plantes eûrent souffert de la sécheresse pendant les jours de sirocco précédents.

D'une façon générale nous pouvons confirmer ce qui a été rapporté par Mitchell (1) : que les stomates restent fermés quand l'humidité de l'atmosphère s'abaisse au dessous de 30%.

Ainsi le 19 Juin, 1939, jour de sirocco grave, nous attendîmes en vain jusqu'à une heure de l'après-midi l'ouverture des stomates d'un plant poussant dans un pot et placé dans le laboratoire. La haute température (33°C.) et l'humidité basse (21%) expliquent ce résultat. Cependant, on constata en même temps une ouverture considérable dans un plant qui se trouvait en serre où l'humidité était un peu plus grande.

De même nous trouvâmes les stomates de jeunes plants en pleine terre fermés à 10 heures 30 le 9 novembre 1948, jour de sirocco, avec une humidité de 27%.

Une dernière série d'observations fut initiée en Novembre 1948 dans le but d'ajouter encore quelques observations avant de publier les résultats de cette étude.

On a trouvé à nouveau que l'état des stomates dans des épidermes plongés immédiatement dans le dioxane correspond assez bien à celui des fragments observés dans l'air. Cependant les conditions climatiques de la saison hivernale étaient défavorables à l'obtention d'ouvertures larges.

Par l'observation de stomates individuels marqués, on s'est convaincu que les stomates se rétrécissent considérablement, si l'on remplace l'air par le dioxane, dans des parties placées entre lame et lamelle. La "fixation" de l'état naturel est donc liée à la condition d'un transfert immédiat des coupes dans le liquide.

Par jours d'humidité normale, l'inclination des stomates à l'ouverture est prononcée, surtout pendant la matinée.. Dans ces conditions, les ostioles stomatiques de feuilles détachées restent largement ouverts pendant longtemps (dans un cas jusqu'à une heure), et cela se vérifie même dans des fragments d'épiderme tenus dans l'air, entre lame et lamelle.

La forme des stomates est largement elliptique et parfois ronde. L'ostiole occupe à peu près les 30 à 40% de la longueur des cellules de bordure qui varie de 8 à 18 microns.

Des essais entrepris en vue d'établir l'ouverture des stomates sur des pellicules de collodium ont rendu des résultats peu satisfaisants.

RESUMÉ

Parmi les diverses méthodes qui ont été développées pour le mesurage de l'ouverture des ostioles stomatiques de la tomate, la fixation immédiate de fragments d'épiderme dans le dioxane a rendu les meilleurs résultats.

BIBLIOGRAPHIE

1. MITCHELL, J. W. (1936). Effect of atmospheric humidity on rate of carbon fixation by plants. *Bot. Gaz.* 98(1) :87—104.
2. NADEL, M. (1940). Sur la mesure de l'ouverture des stomates. (Critique de la méthode de fixation des stomates par l'alcool). *Palestine Journ. Bot. Reh. Series* 3 :24—64.
3. SACHS, J. (1884). Ein Beitrag zur Kenntnis der Ernaehrungsthaetigkeit der Blaetter. *Arb. bot. Inst. Wuerzburg* 3 :1—33.
4. WENT, W. (1944). Plant growth under controlled conditions. III. Correlation between various physiological processes and growth in the tomato plant. *Am. J. Bot.* 31 :597—618.

GERMINATION OF CITRUS SEEDS IN RELATION TO CERTAIN NURSERY PRACTICES

By D. L. ELZE

Division of Citriculture and Agricultural Botany, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot, Israel

I. INTRODUCTION

Though many millions of citrus seedlings are grown commercially in subtropical and tropical countries, nursery methods employed by seedsmen still lack a sound scientific foundation. This was pointed out by OPPENHEIMER (4) more than twenty years ago and is still true, as one may easily learn from the chapter on nursery methods by WEBBER in the recently published second volume of the handbook "The citrus industry". In this connection the following report on the germination of citrus seeds may be welcome. It concerns essentially storage and extraction problems, but the depth of sowing has also been studied.

II. THE INFLUENCE OF FRUIT PULP AND JUICE ON GERMINATION

In text-books on citrus growing the advice is given to wash the seeds immediately after their extraction from the fruit. However, many nurserymen still prefer to keep the fruits in barrels in water. Here they undergo a slow process of decay which facilitates the separation of fruit and seed by softening the former, but seems to exert an adverse influence on the viability of the seeds. Others believe that the slight fermentation setting in when partly cleared seeds are kept in water for 1—2 days facilitates their cleaning and exerts a favourable effect on germination (2).

TABLE I.

Influence of preservation of citrus seeds in fruit juice or water on germination

Date of immersion	*Species*	*Treatment*	*Number of seeds*	*Percentage of germination*
5.10.1942	Sweet lime	1 day in water	20	75
	„ „	1 „ „ juice	20	45
13.10.1942	Sweet lime	9 days in water	24	58
	„ „	9 „ „ juice	24	21
18. 2.1943	Sour orange	4 days in water	60	90
	„ „	4 „ „ diluted juice	60	93
	„ „	4 „ „ pure „	60	92
	„ „	4 „ „ boiled „	60	85
10. 3.1943	Sweet lime	9 days in water	60	96
	„ „	9 „ „ diluted juice	60	82
	„ „	9 „ „ pure „	60	84
	„ „	9 „ „ boiled „	60	82
10. 3.1944	Sour orange	8 days in water	39	77
	„ „	8 „ „ juice	39	55

Table I sums up the results of preservation of citrus seeds in unsterilized juice pressed from the actual parent fruits. The juice was boiled or diluted in certain cases, in order to test the influence of thermically unstable germination inhibitors, if such should be present.

The results of these experimtnts, though not permitting final conclusions, suggest that the juice of citrus fruits has an adverse influence on the final germination percentage in the early days of the ripening season, but this effect, if apparent at all, is slight at the end of the season. Dilution or boiling of juice did not appreciably change the results at the end of the season and was not tested at its beginning; it may be worth while to repeat the experiments in autumn under sterile conditions.

III. INFLUENCE OF FRUIT STORAGE

Sour orange fruits were stored for about three weeks in the laboratory. Two fruits remained nearly sound; they contained a total of twenty seeds. Four fruits with 53 seeds were heavily attacked by brown rot caused by *Phytophthora sp.* while the rest, 13 fruits, were apparently attacked by *Penicillium sp.*, 6 slightly, the others heavily; each of the latter two lots contained a total of 63 seeds. In this experiment low germination percentages were found for seeds from healthy as well as from rotting fruit. About 70% germinated of the seeds from fruit which remained sound and the same percentage was reached by the seeds from fruit attacked by *Penicillium*, irrespective of the degree of fungus development. On the other hand, brown rot seemed to lower the percentage of germination to only 60%. The results are in line with unpublished studies of the Division of Plant Pathology of this station where *Phytophthora* attacking citrus fruit was found much more dangerous to the seeds than *Penicillium*.

In another case fruits of *Poncirus trifoliata* were stored for six weeks, and their seeds sown side by side with seeds from fruit just picked from the tree. In both lots about two thirds of the seeds germinated, but the seeds from the stored fruit germinated about one month later than those from fresh fruit. The same difference resulted from a similar experiment with rough lemon (see table II).

TABLE II.

Germination of seeds from fresh and stored fruits of Rough Lemon sown on 22nd November 1942.

Origin of seeds	*No. of seeds*	*Date of first germination*	*Percentage of germination on Jan. 10th 1943*	*on Febr. 1st 1943*
From fresh fruit, picked 20.11.'42	60	20.12.1942	58	87
From stored fruit, picked 4.10.'42	57	20.12.1942	33	84
From stored fruit, seeds floating on water	9	10. 1.1943	11	67

As we learn from the table, germination of seeds from stored fruit took place after a considerable delay, as compared with seeds from fruit freshly picked from the tree. A few seeds of the former, which floated when placed in water and were sown separately, were delayed even more, and reached a lower final percentage. As WEBBER (6) pointed out, such seeds may contain a considerable percentage of empty embryo-sacs. Further observations on the influence of fruit storage on germination were made in connection with stratification experiments which will be described below. In these cases too, the germination of seeds from stored fruit was somewhat delayed (cf. tables III, IV and V and the general discussion of these experiments on p. 78).

IV. INFLUENCE OF STRATIFICATION AND OTHER STORAGE METHODS

WEBBER (6; p. 4) has stated: "Sometimes the seed is harvested in the early winter, stratified in clean sand, and kept through the winter in a cool, damp cellar. This is not a practice to be generally recommended". In contrast to this rather negative judgment, which does not seem to be founded on experimental evidence, we obtained favourable results with stratification of citrus seeds.

Our first experiment was made in the 1943—44 season with *trifoliata* seeds. On February, 10th, 300 seeds taken from freshly picked fruits were sown. A second lot of 300 seeds from the same fruits was put in one layer on pure, coarse sand in a flower pot and covered with a layer of about 15 cms. of the same sand. The contents of the pot were thoroughly watered, but care was taken that sufficient drainage could take place. After four weeks, on March, 6th, 200 of these seeds were sown. The seeds sown on February, 10th started germinating on March, 10th, but on March, 19th, not more than 11 of the 300 seeds had germinated. On the other hand, of the 200 stratified seeds sown on March 6th 85 seeds already had germinated on that day. The corresponding figures were on April 9th, 58 and 119, and on May 2nd, 84 and 129 seeds or 28% and 65% respectively.

After these strikingly favourable results with stratification of *trifoliata* seeds, more experiments on a somewhat larger scale were made with seeds of sweet lime, rough lemon and sour orange. These experiments were started with sweet lime on December 28th 1944 and with rough lemon and sour orange on January 12th 1945. For each species, the influence was studied of 2, 4 and 6 weeks of stratification as compared with the germination of seeds from fresh fruit sown at the outset of the stratification period. Further sowings were carried out with seeds from fruits just picked from the tree at the end of each stratification period, i.e. 2, 4 and 6 weeks after its beginning. Seeds from fruit picked at the beginning of stratification, but stored for 2, 4 or 6 weeks in the laboratory, were also sown.

In order to compare stratification with other more usual storage methods, seeds removed from fresh fruit were kept for the same periods as stratified seeds either in dry, coarse sand or in powdered charcoal. Hermetically closed jars were filled with these materials and the seeds were well mixed with them after thorough washing and superficial drying. High humidity resulted in the jars, and fungi developed on some seeds. In this way some sweet lime seeds were spoiled (15—19 seeds per jar), but the damage did not increase with time, and was worth mentioning only in sand, while no damage resulted in charcoal. This held true also for rough lemon and sour orange seeds even when kept in sand. By contrast, no growth of fungi or other harmful organisms was observed on the stratified seeds.

All sowings were carried out in a glass-house. The stratified seeds were kept outdoors, but care was taken that the sand did not become too wet during rainy periods, and not too dry, when the rains ceased. The jars were kept in a cool laboratory, together with the stored fruits.

We learn from tables III to V that in contrast to the results obtained in the preceding season with seeds of *Poncirus trifoliata*, none of the treatments had a pronounced influence on the final germination percentage. However, if we compare the germination of seeds sown at the outset of the experiments (December 24th 1944 for sweet lime, January 12th 1945 for rough lemon and sour orange) with that of seeds which underwent other treatments, we find that in general, the germination of the former proceeded at a slower pace. Only a few seeds sown early without stratification or storage sprouted earlier.

Because of this protracted germination of the seeds sown immediately after their removal from the fruit, the germination of stratified seeds sown much later soon reaches the same level or even surpasses it. Thus sweet lime seeds immediately sown on December 24th started germinating only after 35 days, i.e. on January 28th, whereas seeds stratified for 2 weeks and sown on January 9th (cf. table III, treatment 4) began to germinate after 26 days, i.e. on Febr. 4th; their germination percentage, on Febr. 16th already exceeded that of the non-stratified seeds sown early. Germination of seeds stratified for 4 or 6 weeks also began after 25 days (cf. table III, treatments 9 and 14). We may conclude, therefore, that lengthening the stratification period beyond two weeks did not improve the rate of germination.

Similarly, germination of sour orange seeds sown fresh on January 14th (cf. table V, treatment 1) set in after one month, while stratified seeds sown on January 31st germinated already after three weeks. On March 11th 65% of the seeds sown on January 14th had germinated, as against 42% of the stratified seeds sown 17 days later. However, on March 27th these percentages were 68 and 79%, respectively, i.e. in favour of the stratified lot. The germination of rough lemon seeds sown at the same date as sour orange, proceeded in conformity with these observations, but at a slightly faster rate.

TABLE III.

Germination of seeds of Sweet lime after stratification and other treatments

Origin of seeds and treatment	*Date of sowing*	*No. of seeds*	*Beginning of germination*	*Percentage of germination on* 18.2.45	4.3.45	18.3.45	1.4.45	24.4.45
1. Fresh seeds of fruits picked on 20.12.44	24.12.44	210	28.1.45	32	53	75	80	84
2. do., picked on 7.1.45	9.1.45	163	9.2.45	29	54	78	80	82
3. do., kept from 20.12.44 to 7.1.45	8.1.45	133	4.2.45	18	37	62	71	78
4. Seeds stratified from 24.12.44 to 8.1.45	9.1.45	120	4.2.45	36	65	80	80	83
5. Seeds kept from 24.12.44 to 9.1.45 in charcoal	9.1.45	106	5.2.45	50	63	79	80	80
6. do., in sand	9.1.45	93	4.2.45	48	69	84	84	84
7. Fresh seeds of fruits picked on 21.1.45	22.1.45	136	18.2.45	3	37	74	77	80
8. do., kept from 20.12.45 to 22.1.45	23.1.45	129	18.2.45	1	50	76	82	84
9. Seeds stratified from 24.12.44 to 24.1.45	24.1.45	88	18.2.45	3	53	78	89	91
10. Seeds kept from 24.12.44 to 24.1.45, in charcoal	24.1.45	110	18.2.45	3	69	91	94	94
11. do., in sand	24.1.45	92	18.2.45	5	68	82	82	86
12. Fresh seeds of fruits picked on 6.2.45	8.2.45	100	8.3.45	—	—	58	84	92
13. do., kept from 24.12.44 to 10.2.45	11.2.45	145	9.3.45	—	—	36	79	87
14. Seeds stratified from 24.12.44 to 11.2.45	11.2.45	120	6.3.45	—	—	52	87	88
15. Seeds kept from 24.12.44 to 12.2.45, in charcoal	12.2.45	118	9.3.45	—	—	39	69	76
16. do., in sand	12.2.45	106	8.3.45	—	—	52	92	94

TABLE IV.

Germination of seeds of Rough lemon after stratification and other treatments

	Origin of seeds and treatment	*Date of sowing*	*No. of seeds*	*Beginning of germination*	*Percentage of germination on* (1945) 5.3.	11.3.	18.3.	27.3.	1.4.	20.4.
1.	Fresh seeds of fruits picked on 10.1.45	12.1.45	111	9.2.45	56	79	81	81	81	86
2.	do., picked on 24.1.45	26.1.45	114	22.2.45	22	54	70	87	98	100
3.	do., kept from 10.1.45 to 27.1.45	28.1.45	120	25.2.45	9	51	71	82	90	92
4.	Seeds stratified from 12.1.45 to 29.1.45	29.1.45	92	22.2.45	35	79	95	100	100	100
5.	Seeds kept from 12.1.45 to 1.2.45 in charcoal	1.2.45	123	28.2.45	9	43	61	69	94	94
6.	do., in sand	1.2.45	121	22.2.45	15	58	76	81	86	86
7.	Fresh seeds of fruits picked on 12.2.45	14.2.45	134	15.3.45	—	—	8	49	83	97
8.	do., kept from 10.1.45 to 12.2.45	15.2.45	130	18.3.45	—	—	2	8	42	88
9.	Seeds stratified from 12.1.45 to 15.2.45	16.2.45	108	11.3.45	—	3	9	39	74	93
10.	Seeds kept from 12.1.45 to 18.2.45 in charcoal	19.2.45	115	11.3.45	—	1	9	38	65	90
11.	do., in sand	19.2.45	114	11.3.45	—	4	39	82	91	95
12.	Fresh seeds of fruits picked on 28.2.45	1.3.45	105	24.3.45	—	—	—	11	56	95
13.	do., kept from 10.1.45 to 26.2.45	27.2.45	129	22.3.45	—	—	—	19	66	97
14.	Seeds stratified from 12.1.45 to 2.3.45	2.3.45	115	15.3.45	—	—	8	72	94	94
15.	Seeds kept from 12.1.45 to 7.3.45, in charcoal	8.3.45	119	18.3.45	—	—	1	9	43	92
16.	do., in sand	8.3.45	119	18.3.45	—	—	3	34	74	92

TABLE V.

Germination of seeds of Sour orange after stratification and other treatments

Origin of seeds and treatment	*Date of sowing*	*No. of seeds*	*Beginning of germination*	*Percentage of germination on* 11.3.45	27.3.45	1.4.45	20.4.45	15.5.45
1. Fresh seeds of fruits picked on 9.1.45	12.1.45	118	11.2.45	65	68	70	75	75
2. do., picked on 25.1.45	26.1.45	120	5.3.45	33	69	76	78	80
3. do. kept from 9.1.45 to 27.1.45	28.1.45	110	5.3.45	13	63	76	85	86
4. Seeds stratified from 11.1.45 to 30.1.45	31.1.4	215	22.2.45	42	79	84	88	88
5. Seeds kept from 11.1.45 to 31.1.45 in charcoal	1.2.45	162	25.2.45	22	75	79	85	85
6. do., in sand	1.2.45	161	25.2.45	38	81	91	91	91
7. Fresh seeds of fruits picked on 12.2.45	14.2.45	143	22.3.45	—	8	48	85	88
8. do., kept from 9.1.45 to 14.2.45	15.2.45	125	25.3.45	—	4	9	73	88
9. Seeds stratified from 11.1.45 to 15.2.45	16.2.45	121	15.3.45	—	26	63	80	87
10. Seeds kept from 11.1.45 to 23.2.45 in charcoal	25.2.45	120	16.3.45	—	61	80	95	95
11. do., in sand	25.2.45	123	11.3.45	—	53	65	95	95
12. Fresh seeds of fruits picked on 28.2.45	1.3.45	107	27.3.45	—	1	19	89	94
13. do., kept from 9.1.45 to 26.2.45	27.2.45	147	29.3.45	—	—	7	83	90
14. Seeds stratified from 11.1.45 to 5.3.45	6.3.45	196	26.3.45	—	3	31	83	87
15. Seeds kept from 11.1.45 to 7.3.45 in charcoal	8.3.45	71	17.3.45	—	1	24	84	84
16. do., in sand	8.3.45	71	18.3.45	—	8	56	90	90

Seeds from fruits just picked from the tree and sown at the same time as the stratified controls (cf. tables III—V, treatments 2, 7 and 12), evinced a slightly retarded germination in comparison with the latter. This was found true especially for seeds of sour orange and rough lemon, irrespective of the length of the stratification period. In the case of sweet lime, only slight differences were found after two weeks' stratification, and none where the treatment was continued for a longer period.

The germination of seeds from fruit stored in the laboratory (tables III—V, treatments 3, 8 and 13) proved to be retarded more that that of seeds from fruit that had meanwhile remained on the mother-tree. Even sweet lime seeds showed pronounced differences after two weeks' storage, but hardly any, where storage extended over four or six weeks. With rough lemon seeds and even more so with those of sour orange, clear-cut differences were evident, irrespective of the length of the storage period.

Generally speaking, the germination of seeds stored in sand or charcoal proceeded at a rate similar to that of seeds stratified for the same periods.

V. THE VIABILITY OF SEEDS OF LOW SPECIFIC WEIGHT

The low germinative capacity of rough lemon seeds floating on water has above been referred to. This phenomenon is, however, more widespread with sweet lime. Table VI indicates the germination of floating sweet lime seeds to be somewhat lower than that of normal seeds that sink to the bottom when immerged in water. Seeds of sour orange, when just removed from the fruit, float on water, even if well developed, owing to the strong imbibition of the peripheric layers of their seed-coat. During stratification, however, this slimy layer is gradually lost, and well developed seeds then sink when immersed in water. It is, therefore, not surprising that we found no differences in the germination percentages of sour orange seeds which had undergone stratification, if they were divided into those heavier, and those lighter than water, since this depends mainly upon the degree of deterioration of the mucilage.

TABLE VI.

Germination of Sweet lime seeds, according to their specific weight

Date of sowing	*Heavier than water*		*Lighter than water*	
	No. sown	*Germination percentage*	*No. sown*	*Germination percentage*
15.10.1942	24	79	12	67
24.12.1944	145	92	65	79
9. 1.1945	150	85	13	69
11. 2.1945	115	90	30	80

VI. THE DEPTH OF SOWING IN THE NURSERY

WEBBER (6) recommends sowing seeds ¾—1 inch deep, but no systematic investigation of the most favourable depth seems to have been undertaken. We made a few observations on this subject. In our first experiment, sweet lime seeds were sown at depths of 1, 3 and 7 cms., respectively. No differences in ultimate germination percentages developed between seeds sown 1 and 3 cms. deep, though the latter emerged later from the soil. Those sown at 7 cms., however, were much delayed and appeared only in low numbers. By digging out the remainder, we convinced ourselves that germination had taken place, but the seedlings failed to reach the soil surface. Some, which eventually emerged, succeeded in doing so with the second pair of leaves only, the first remaining underground.

In a second experiment, rough lemon and sour orange seeds were sown at 1, 2½ and 4 cms., respectively. As we learn from table VII, the depth again exerted an important influence, and it seems remarkable that even at a depth of 2½ cms. germination was still delayed. This was confirmed in a following season.

TABLE VII.

Influence of depth of sowing on germination

Species and date of sowing	*No. of seeds*	*Depth of sowing cm.*	*Beginning of germination*	*Percentage of germination* 3.6.1943	6.6.1943	16.6.1943
Rough lemon sown	15	1	24.5.43	80	87	97
11.5.1943 I	15	2.5	1.6.	50	87	97
	15	4	1.6.	14	40	97
II	15	1	28.5.	80	100	100
	15	2.5	30.5.	60	100	100
	15	4	31.5.	27	60	97
Sour orange sown	15	1	26.5.	88	91	93
11.5.1943	15	2.5	30.5.	29	71	83
	15	4	1.6.	21	50	83
				23.5.'45	25.5.'45	10.6.'45
Sour orange sown	60	1	15.5.	60	72	89
27.4.1945	60	2.5	15.5.	40	61	86
	60	4	23.5.	3.5	11	85

In interpreting the results it should be kept in mind that the second experiment was carried out rather late in the season, under very favourable conditions of temperature. In nursery practice, deeper sowing of the seeds may, therefore, produce a longer delay in germination, owing to lower temperatures during the rainy season, and this may prove of practical importance.

VII. DISCUSSION

The present experiments are too few in number and too restricted in scope to permit final conclusions, the more so as the germination of citrus seeds seems to respond easily to various, little known environmental influences. These may produce considerable variation in the results, if conditions are not strictly controlled, a circumstance evident from the numerous tables in the study of Perlberger and Reichert on the albinism of citrus seedlings (5). Yet there remain some well established facts which seem important and warrant discussion.

From some of the experiments with seeds kept for some time in fruit juice the impression may be gathered that the germination percentage is lowered under the influence of germination inhibitors in the juice, the presence of which was demonstrated by Oppenheimer (3) and others for tomatoes and other fruits. The delayed germination of seeds remaining in ripe fruit for a long while, points in the same direction (cf. table II). But in this case other factors must also be considered. If seeds from fruit kept in the laboratory are delayed in their germination, as compared with seeds sown simultaneously, but taken from fresh fruit, this may also be due to the accumulation of noxious products of intramolecular respiration (alcohol, etc.). This interpretation finds support in the fact that seeds immersed in water for one night after extraction from stored fruit, also germinate with obvious delay, although not more than traces of inhibitors could then still be present. Such treatment underwent the seeds of the extensive storage experiment(cf. tables III—V). It is difficult to explain why seeds kept for a few days in boiled juice germinated in lower numbers than controls.

Fruit storage in rooms instead of seed storage does not seem to be practiced outside Palestine where the sweet lime, our main rootstock, ripens its fruits already in October, but the seeds are often sown only in March. Yedidyah (7) recommends spreading of the fruit in a thin layer on the floor, removing decayed fruits as often as necessary, or preferably, disinfecting them beforehand. Unlike other authors, he insists on the danger connected with the use of seeds from rotting fruit. Our own results demonstrate that it is best to avoid storing fruits. The seeds should rather be extracted at once and should afterwards be stratified or kept in sand or charcoal.

Our studies show that stratification of citrus seeds is to be recommended though only in the case of *trifoliata* was the ultimate percentage of germinating seeds higher than that of untreated seeds. Stratification offers the advantage of an earlier and more regular germination which is more pronounced with sour orange and rough lemon than with sweet lime. Possibly the advantages of stratification would have been still greater, if the seeds had been sown outdoors in a normal, cool winter, instead of being sown in a glass-house and

in an exceptionally warm winter. It seems unjustified to extend the period of stratification for longer than two or three weeks and we must disagree with YEDIDYAH's advice to delay sowing until the stratified seeds begin to germinate.

BARTON (1) stored citrus seeds in open as well as in closed containers, but unlike ourselves, she did not mix them with sand or charcoal. In her experiments, storing wet seeds in closed containers proved injurious already after eight weeks. While this was the case at room temperature, the germinative capacity was much better preserved at 5°C. In the present experiments no unfavourable influence of storage in the laboratory was established, but it should be kept in mind that we did not store seeds for more than 6 or 7 weeks, and temperature in our laboratory may have been lower than in BARTON's. It is remarkable that she succeeded in storing citrus seeds at 5°C for nearly a year without appreciable damage, especially if the containers were open and the seeds thus enjoyed aerobic conditions.

The question whether citrus seeds floating on water should be discarded, remains open. In our experiments such seeds formed an unimportant part of the total, except in the case of sweet lime. Even here, their germinative capacity was by no means very low. OPPENHEIM (2) found that light seeds of sweet lime produce normal seedlings; only extremely underdeveloped seeds proved inferior.

Regarding the optimum depth for sowing the seeds, one centimetre's depth has rendered the best results, and it has been found that even the depth of one inch in sandy soil has some delaying effect on germination. But the nurseryman will not agree to sow as shallow as that, since the seeds will easily dry up during warm weather, before they strike roots. We arrive, therefore at the conclusion that the optimum depth is 2 to 3 cms., as recommended in the text books, or preferably 18—25 mms., as indicated by WEBBER (6).

VIII. SUMMARY

Seed germination of Palestinian sweet lime, sour orange, rough lemon and *Poncirus trifoliata* used as citrus rootstocks has been investigated. Reduced percentage of germination was often obtained by keeping the seeds in fruit juice. They should, therefore, be washed immediately after their extraction from the fruits, instead of being left in rotting fruits mixed with water — a practice still common in citrus nurseries. Infection of the fruits with brown rot was found injurious to the seeds.

Storage of picked fruit has a delaying effect on germination. Stratification of *trifoliata* seeds accelerated germination and raised the number of sprouting seeds. Stratified seeds of sour orange and rough lemon germinated sooner and in a more regular way than unstratified controls. Sweet lime seeds responded but little to stratification. Two weeks' stratification was found sufficient to obtain satisfactory results.

Keeping washed, wet seeds in closed containers mixed with charcoal gave satisfactory results, but caused some loss by fungous infection which grew worse, if dry sand was used instead of charcoal. Stratification was found more advisable than these methods.

Sowing in light soil at a depth of one centimetre proved superior to deeper placing of the seeds. Depths between 2 and 3 cms., which are customary, appear preferable for practical reasons.

Seeds floating on water were found in appreciable number only with sweet lime. Their power of germination was lower than in normal seeds, but their small numbers let it appear doubtful, whether they are worth of being separated from normal seeds and discarded.

REFERENCES

1. Barton, L. V. (1943). The storage of citrus seeds. *Contr. Boyce Thompson Inst.* 13 :47—55.
2. Oppenheim, J. D. (1932). Citrusfruechte. Berlin und Leipzig, 158 pp.
3. Oppenheimer, H. R. (1923). Das Unterbleiben der Keimung in den Behaeltern der Mutterpflanze. *Sitz.- Ber. Ak. d. Wiss. Wien, math.- nat. Kl.* 131 :279—312.
4. Oppenheimer, H. R. (1928). Physiologische Probleme bei der Citrus-Anzucht. *Angew. Bot.* 10 :103—109.
5. Perlberger, J. & Reichert, I. (1938). Experiments on the control of albinism in citrus seedlings. *Pal. Journ. Bot., Reh. Ser.*, 2 :40—77.
6. Webber, H. J. (1948). in Batchelor, L. D., & Webber, J. H. The citrus industry, volume II. *Berkeley and Los Angeles.*
7. Yedidyah, S. (1937). Citrus growing (Hebrew), Tel Aviv.

THE CARBON DIOXIDE CONTENT OF THE AIR IN A CITRUS ORCHARD (1)

By S. P. MONSELISE
School of Agriculture of the Hebrew University, Rehovot

The carbon dioxide content of the air was measured in a citrus grove at Rehovot, by means of a conductimetric method. The apparatus has been described by HOLDHEIDE, HUBER & STOCKER (3). The trees were planted by the hexagonal system at a distance of 5 metres. The orchard is situated in a region where most of the agricultural land is planted with citrus groves. Ten consecutive double determinations were made during periods lasting 1½—2 hours, in the morning or in the afternoon (between 08.30 and 12.00 or 14.00 and 17.00, respectively) on 14 days over the period from July, 1946 to July, 1947. The air was sampled at about 1.30 m. above the soil, simultaneously from the interior of a „Marsh Seedless" grapefruit tree (near the trunk) and at the perimeter of its leafy top. At the same time records of wind velocity were taken by means of a dry katathermometer at the perimeter of the top, near the place where air samples were taken.

The carbon dioxide content was calculated both as mg per litre air, and as percentage of weight. The latter procedure offers the advantage that it delivers strictly comparable data by elimination of the error caused by changes of density induced by temperature changes.

No significant differences in the carbon dioxide content of the air were found between the inner and the outer portions of the tree. The averages have therefore been calculated from data taken from both points. The results are summarized in table I.

Our values are markedly below those reported earlier for open localities (6). Only during the night have such "normal" values been attained (see table I). No significant differences between "morning" and "afternoon" have been detected. No relations between wind velocity and carbon dioxide content of the air have been found for the reasons already discussed by LEHMANN (5).

If the results expressed as percentages of weight, are plotted against mean temperature obtaining at every period of measurement, a curve, as presented in fig. 1, results. It is a minimum curve with its lowest figure at about 28°C. The downward trend in the percentage of carbon dioxide, is evidently caused by the photosynthetic activity of the citrus trees, which increased up to 28°C. As a consequence, the air was progressively depleted of its carbon dioxide.

(1) This paper constitutes a chapter of the doctor's thesis of the author, presented to the Senate of the Hebrew University, in October, 1949.

TABLE I.

Mean carbon dioxide content of the air, and mean wind velocity in a citrus grove

	Time of day	No. of determinations	Mean temp. C°.	CO_2 mg/litre	Coeff. of variability	CO_2, % of air weight	Wind veloc. m/sec.
16 & 18.7.46	morning	40	29.4	0.4475	11.0%	0.03912	—
15 & 18.7.46	aftern.	42	29.5	0.4510	10.5	0.03938	—
8.10.46	morning	19	27.9	0.4149	9.6	0.03570	0.25
8.10.46	aftern.	19	26.3	0.4457	8.1	0.03758	0.53
9.12.46	morning	20	16.0	0.4720	8.9	0.03899	0.92
8.12.46	aftern.	20	15.9	0.4870	13.0	0.04018	0.50
7.1.47	morning	18	15.2	0.4840	12.8	0.03964	—
12.1.47	aftern.	22	16.9	0.4698	11.0	0.03886	0.82
26.2.47	morning	20	19.4	0.4785	13.5	0.04004	0.29
26.2.47	aftern.	20	20.3	0.4723	8.4	0.03965	0.44
4.5.47	morning	19	29.2	0.4438	12.5	0.03879	0.30
4.5.47	aftern.	19	27.3	0.4602	8.2	0.03891	0.28
18.7.47	morning	20	30.4	0.4829	11.1	0.04257	—
17.7.47	aftern.	20	31.0	0.4951	9.4	0.04365	—
averages	—	—	—	0.4646	10.8	0.03958	0.48
25 & 26.7.46	night	36	23.8	0.5480	8.7	0.04691	—

From 28°C upwards, the assimilation rate was apparently reduced, while the respiration rate increased further. This seems to account for the very steep increase in CO_2.

A temperature optimum for photosynthesis at 28°C may seem a little too low for trees indigenous in hot climates. Yet this figure may not appear implausible in the light of the following considerations.

1. According to STALFELT (11), the optimum temperature for photosynthesis is lowered increasingly, the longer the time of uninterrupted exposition to relatively high temperatures. Similar conclusions had already been drawn by MATTHAEI (7).

2. The temperatures noted in table I are averages measured in the solution of the vessels absorbing the CO_2 gas, which were placed in the shade. They are, of course, lower than the temperature of a large part of the leaves of the tree, which were more or less exposed to the sun rays [see KONIS (4)]. The photosynthetic activity of such leaves may be very low, as shown by NUTMAN (9) for coffee leaves in Tanganyika.

3. Citrus trees, as shown elsewhere (8), may grow quite well in partial shade [see also (1, 13)]. According to GUTTENBERG (2), many Mediterranean evergreens show maximum photosynthesis during spring, while the values recorded in the hot summer months are relatively lower. Experiments with irrigated plants reported by others have shown that water supply is not the only factor responsible for such behaviour.

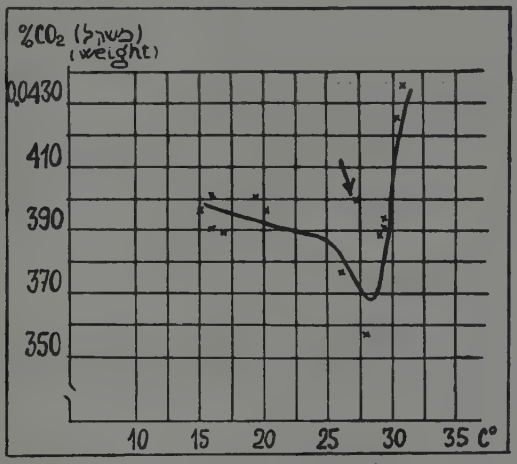


Fig. 1. — Carbon dioxide content of air as weight percentage plotted against the temperatures obtaining while samples were taken.

Note. — The point, marked by an arrow, has been established on a scirocco (khamsin) day. On such a day the photosynthetic activity of citrus trees is probably low owing to stomatal closure, caused by low air moisture rather than by high temperatures (10). This seems to support our view that photosynthesis is the main factor responsible for the fluctuations.

Our values of carbon dioxide content of the air are in good agreement with the data of VERDUIN and LOOMIS (12) who found averages ranging near 0.450 mg per litre in summer, in maize fields, between 08.00 and 18.00. This figure closely approaches our summer averages of 0.463. Accepting 0.594 as normal (12) a mean decrease of 21.9% is found which must be attributed to photosynthesis.

REFERENCES

1. FILIPENKO, I. A., GERBER, E. H., & ELPIDINA, O. K. (1938). Photosynthesis in citrus trees under natural conditions of growth. (Russian) *Soviet Subtropics* 44:50—52.

2. GUTTENBERG, H. von (1927). Studien ueber das Verhalten des immergruenen Laubblattes der Mediterranflora zu verschiedenen Jahreszeiten. *Planta* 4:726—779.

3. HOLDHEIDE, W., HUBER, B., & STOCKER, O. (1936). Eine Feldmethode zur Bestimmung der momentanen Assimilationsgroesse von Pflanzen. *Ber. D. bot. Ges.* 54:168—188.
4. KONIS, E. (1943). The thermic balance of plants in Palestine. (Hebrew) Dissert. Ph. D., Hebrew University.
5. LEHMANN, P. (1929). Der Einfluss der Turbulenz auf den Kohlensaeureumsatz in Pflanzenbestaenden. *Fortschr. d. Landw.* 4:745—751.
6. LUNDEGARDH, H. (1931). Environment and plant development. (Transl. Ashby) London.
7. MATTHAEI, G. L. C. (1905) as cited by MILLER, E. C. (1938) Plant Physiology, McGraw Hill, N. Y. (page 594).
8. MONSELISE, S. P. (1949). Ecological conditions in the grove and carbon assimilation by citrus trees. (Hebrew) Diss. Ph. D., Hebrew University.
9. NUTMAN, F. J. (1937). Studies on the physiology of Coffea arabica. I. Photosynthesis of cosee leaves under natural conditions. *Ann. Bot. N. S.* 1:353—367.
10. OPPENHEIMER, H. R., & MENDEL, K. (1939). Orange leaf transpiration under orchard conditions. I. Soil moisture high. *Pal. J. Bot. Reh. Ser.* 2:171—250.
11. STALFELT, M. G. (1939). Ueber die Natur der Licht- und Temperaturoptima in der Kohlensaeureassimilation. *Svensk. Bot. Tidskr.* 33:383—417.
12. VERDUIN, J., & LOOMIS, W. H. (1944). Absorption of carbon dioxide by maize. *Pl. Phys.* 19:278—291.
13. WEBBER. J. H., & BATCHELOR, L. D. (1943, 1948). The citrus industry. Vol. I., Vol. II. The Calif. Univ. Press.

THE MANGANESE CONTENT OF SHAMOUTI ORANGE LEAVES

By AMICHAI COHEN
School of Agriculture of the Hebrew University, Rehovot

I. INTRODUCTION

Recent research in citrus nutrition has shown that soils are often deficient in microelements such as zinc, copper, boron and manganese, and that the supply of such elements is essential for normal growth and fruit production. In their absence, more or less characteristic patterns are observed in the leaves which disappear, as a rule, after the deficient element is supplied to the soil or sprayed on the leafy top in solution. Pioneer work in this field has been done in Florida by CAMP and his associates (5).

The citrus soils of Palestine are often deficient in zinc, as shown by a leaf chlorosis known in California as "mottle leaf" and in Florida as "frenching". PERLBERGER (17) has shown that the trouble can be remedied successfully by spraying with zinc sulphate solutions or by their injection into the trunks or scaffold branches under pressure. OPPENHEIMER (15) found indications of magnesium deficiency in orange leaves as well as in grapefruits. So far, no cases of typical copper or boron deficiency have been reported in this country, while iron deficiency is widespread on calcareous, alkaline soils.

Experiments undertaken by the Division of Citriculture and Agricultural Botany of the Agricultural Research Station, Rehovot, from 1947 onwards aim at the correction of zinc and magnesium deficiency. Leaf patterns suggest that both deficiencies appear together mostly in poor, sandy soils, and symptoms suggesting the lack of both elements are often observed on one and the same tree.

In addition to these leaf patterns, OPPENHEIMER has observed a third type of leaf chlorosis which he suspected to be due to manganese deficiency. It appears on Shamouti and mandarin leaves and looks much like the malnutrition symptoms described and illustrated for manganese deficiency by BRYAN (3), CAMP & FUDGE (5) CHAPMAN (6) and others (18). The chlorophyll fades between the lateral veins of the affected leaves. Central and lateral veins, however, remain green, and this is true also for trophenchymatic tissue bordering upon them immediately, and for the peripheric portion of the leaves. The transition from this green tissue, following the veins in the shape of narrow irregular bands, and the yellowish intercostal zones is not abrupt, as in typical cases of zinc deficiency, but gradual and indistinct, and this fact suggested manganese deficiency.

Affected leaves were of normal size, appearing, as a rule, only on the third, late-summer flush of vegetative growth.

The purpose of the present study was: (1) to establish the manganese content of leaves appearing healthy and of abnormal leaves from affected trees, to compare it with that of healthy Shamouti trees, both growing in or near one locality on four different soil types: loam, loamy sand, dune sand and calcareous sand (Kurkar); (2) to establish the character of the trouble by supply of manganese salts for diagnostic purposes. For this end manganese sulphate was (a) introduced as crystals into holes bored in the wood of affected branches or (b) applied as a spray in solution.

II. SOILS

Since aeration and reaction of the soil determine the availability of manganese to a large extent the following data regarding the mechanical composition and the pH of the soil types seem appropriate.

(1) The sand was found composed of 7.4% coarse sand, 82.4% fine sand, 10.2% silt and clay. The pH of such sand is 6.7 to 7.6 and its MnO content 0.016—0.020% (unpublished data of Prof. S. Ravikovitch).

(2) The loam had 2.2% coarse and 69.6% fine sand with silt and clay forming together 28.2% of the total.

(3) The loamy sand of the survey was actually sand underlain with loam. The data under (1) and (2) convey an idea of its composition. The pH was 7.6 to 8.1, falling with depth.

(4) The kurkar was not analysed. According to unpublished data by HEYMANN-HERSCHBERG it contains 8.2—11.3% coarse, 81.3—85.8% fine sand, only 5.9—7.4% silt and clay. 24% of the total was calcium carbonate. The pH of kurkar is about 8.3, but reaches sometimes 8.5. Total MnO is according to RAVIKOVITCH as low as 0.008%.

In soils (1)—(3), which are well aerated and of nearly neutral reaction, the Mn might be assumed to be readily available, while the low Mn content and the pronounced alkaline reaction of the kurkar soil could be expected to offer unfavourable conditions for the uptake of this mineral by citrus trees. It should be recalled in this connection that manganese is usually present in soils of acid reaction in its bivalent form which is easily available to the plant. Above pH 6.5 Mn shows a tendency to transformation into the tetravalent insoluble form, which takes place under oxidation. With pH higher than 7.5, the prevalence of tetravalent manganese is very great, especially in well aerated soils, and the mineral becomes more or less unavailable to plants.

III. METHODS

Sampling

In each of the groves of Shamouti orange on sweet lime stock that were selected for analysis, groups of trees were chosen which showed the type of leaf chlorosis described above. Composite samples of 30 leaves each, from the last spring's growth, were plucked from fruit stalks about the middle of January 1948, i.e. under conditions of winter dormancy, according to directions of BATHURST (2). One half of the samples was taken from northern, the other from southern flanks of the Shamouti trees.

It must be emphasized that the type of deficiency chlorosis in question was never found alone: the affected trees evinced also symptoms of either zinc or magnesium deficiency or of both. We were therefore obliged to choose leaves from trees where the symptoms suspected to indicate manganese deficiency were preponderant. The leaves plucked for analysis looked healthy, but it was assumed that they would render low figures of manganese, if the trees suffered at all of manganese deficiency.

In the neighbourhood of the chlorotic trees, control samples were taken from healthy specimens growing in the same type of soil. All trees were well cultivated and bore ample fruit when they were sampled.

Analytic Procedure

Immediately after collection the leaves were washed in the laboratory with distilled water and were dried in an electrical drying oven at 105°C., to avoid any losses of dry matter by respiration.

They were then pulverized in a Pyrex mortar, and the powder kept in cellophan bags. All reagents used were of a high standard of purity, as was also confirmed by blank analysis.

The analytical method used was that of WILLARD & GREATHOUSE (19), modified by COLEMAN & GILBERT (7). The basic principle of this method is the oxidation of the bivalent manganese to the septemvalent permanganate form. For oxidation we used KIO_4 considered as the most reliable reagent for this purpose. The quantity of the permanganate formed was determined by aid of an American "Lumetron" photoelectric colorimeter. By adjustment of the mass of leaf powder weighed for analysis (1—4 grams) and the colour intensity thus obtained to the range of maximum sensitivity of the colorimeter, we arrived at readings exact to ±0.25%. Such a degree of exactness was obtained if 40—50 gamma of manganese were present in the measuring flasks containing 13 ml. each.

The leaf powder was burnt to white ashes in an electrical oven at 600°C. The ashes were dissolved in HNO_3 and the manganese in the solution oxidized by KIO_4. Reduction of the permanganate thus obtained was avoided by careful exclusion of reducing substances like chlorine, sulphur dioxide, volatile organic substances, etc. The water was redistilled after oxidation of any reducing organic compound that might be present. The colorimetric reading was further carried out immediately after oxidation of the manganese to permanganate, in order to avoid its partial reduction to achromatic compounds.

Two analyses of the same sample rarely differed from each other by 5%; in most cases the variation remained within a range of 2—4%.

IV. RESULTS

The total number of analyzed samples was eighty, each carried out in two repetitions, five samples being taken in each of the four groves, 1) from healthy appearing and 2) from affected trees, a) from northern and b) from southern flanks. The results are not published in full, but the averages of five equivalent samples of each combination are presented in table I.

TABLE I.

Average manganese content of apparently healthy Shamouti leaves from trees budded on sweet lime stock (p.p.m. of dry matter).

Soil type	Flank	Chlorotic trees		Healthy trees		Average chlorotic and healthy
		Mn p.p.m.	Average N+S / 2	Mn p.p.m.	Average N+S / 2	
Loam	N	32,0	35,06	30,5	30,52	32,79
	S	38,1		30,5		
Loamy Sand	N	36,0	35,82	24,3	24,55	30,19
	S	35,6		24,7		
Sand	N	32,6	29,37	24,0	21,75	25,56
	S	26,1		19,5		
Limy Sand (Kurkar)	N	16,0	15,66	16,4	16,38	16,02
	S	15,2		16,3		
Average of all soil types			28,98		23,30	

A two-factorial analysis of variance (soil; leaf-colour) yielded the following significant differences:

	$p=0.05$	$p=0.01$
between soils	4.45	5.85
between chlorotic and healthy trees	2.95	3.88
between any two means	5.93	7.79

Accordingly the following conclusions can be drawn from these data:

(1) Average figures of manganese content fluctuate between 15.7 and 35.8 p.p.m., the general average being 26.1.

(2) There are no consistent differences between southern and northern flanks of the trees.

(3) Apparently healthy leaves from trees evincing (on other leaves) symptoms described by various authors as characteristic of manganese deficiency are as a rule not lower but higher in manganese content than control leaves from healthy trees. This difference is even highly significant.

(4) The composition and reaction of the soil has a pronounced effect on the manganese content. The difference between loam and loamy sand on the one hand and sand on the other hand is significant at the 0.01 and the 0.05 levels, that between sand and kurkar at the 0.01 level.

The manganese content decreases, especially in the leaves from healthy specimens, with diminishing contents of fine soil particles (silt and clay) which can be assumed to contain the bulk of manganese compounds. On the other hand the manganese content of leaves from healthy as well as chlorotic trees is decidedly lower in the grove with kurkar soil, where soil reaction is pronouncedly alkaline, than on the other soil types where reaction is nearly neutral or but slightly alkaline.

After the results had been obtained, the author wished to establish whether leaves with pronounced manganese deficiency symptoms would prove lower in manganese than others, apparently healthy from the same trees. For this purpose such leaves were collected from trees of the grove on loamy sand, in the Research Station of Rehovot. The following results were obtained:

Average of five samples of (a) chlorotic leaves: Mn 47.0 p.p.m.
(b) healthy leaves: Mn 47.3 p.p.m.

The samples were taken from the recent September growth which, as we have stated, is the only one showing the deficiency symptoms in question. One year old green leaves taken next to fruits from the same trees rendered a lower average figure, viz.: 35.8 p.p.m.

V. DISCUSSION

Recent research in various countries, such as South Africa, California and Palestine has led to the conviction that foliar analysis is a highly valuable tool for the establishment of nutritional disorders in citrus trees. These investigations have indicated that for each nutrient specific normal concentrations can be indicated which are relatively independent of climate and stock and mainly determined by the physiological properties of the variety. In many cases minimum levels can be indicated, below which we are entitled to speak of a deficiency that needs correction.

While earlier studies of Haas (8) failed to establish consistently lower figures of manganese in leaves showing deficiency symptoms as compared with normal ones, more recent research has been more fruitful in this respect. The results of this work are summarized in table II.

TABLE II.

Normal and abnormal manganese content of citrus leaves according to various authors (p.p.m.)

Investigators	Variety	Deficiency range	Normal range	Leaves sprayed with Mn salt solutions	Excess range
BATHURST, 1943	Valencia or.	<10	20—50		>100
CHAPMAN, et al. 1939	„ „	<10	18		
LEVITT & NICHOLSON, 1941	„ „	<7—10	18—20		
CHAPMAN et al., 1939	Washington Navel orange	<7	20		
LEVITT & NICHOLSON, 1941	Marsh grapefruit	<11	25—30	34.7	
CHAPMAN et al., 1939	Sour lemon	<5	14—26	75	
HAAS, 1932	„ „	<4	10.7—17		
CAMP & FUDGE, 1939	Parson Brown orange		28	45	
OBERHOLZER, 1946	Citrus sp.		20—40		1000

In this table the figures for oranges suggest that an acute manganese deficiency is correlated with manganese figures below 10 p.p.m. Normal leaves contain 20 to 50 p.p.m., while 10 to 20 p.p.m. seem to represent a "poverty adjustment range" (13) where supply of the nutrient is poor but we are not entitled to speak of an acute deficiency.

Comparing the results of foreign investigators with the results of our own studies we arrive therefore at the conclusion that our trees did not suffer from manganese deficiency. The leaves from groves on loam, loamy sand and sand were evidently well provided with manganese and only on kurkar their manganese content falls into the poverty adjustment range. The lower content of manganese of trees on kurkar soil may be due to three different properties of this soil type: (1) its alkaline reaction, (2) high aeration and (3) low water storage capacity. The latter implies under ordinary irrigation schemes a periodic shortage of water supply known to have an unfavourable influence on manganese absorption [LUNDEGARDH (12) and others].

The fact that the trees in the loamy sand were able to absorb sufficient manganese is remarkable, since the pH was found higher than 7.5 in all soil layers to a depth of 1.20 metres. While short-lived field crops are, as a rule, unable to absorb sufficient manganese at pH figures above 7.5 where manganese salts become insoluble in water, citrus trees may be able to do so by prolonged excretion of acids by their roots. The roots of sweet lime stock have already been shown (16) to absorb minerals even when present in not readily available form. They further may extract the nutrients from still deeper soil layers, where the reaction may be less alkaline.

If we are led to the conclusion that the type of chlorosis investigated is probably not produced by manganese deficiency, this is further corroborated by the negative results of our spraying and injection experiments mentioned above. Neither spraying with a neutralized 1% $MnSO_4$ solution in March, which adhered well to the leaves, nor introduction into drilling holes driven into the wood of as much as 1 to 3 grammes of solid manganese sulphate per skeleton branch proved effective in remedying the deficiency within a period of more than six months. The nature of the deficiency thus remains obscure. It seems improbable that the pattern is produced by lack of iron since iron can neither be suspected to lack in the soils investigated nor to become non-available in soils with reactions below pH 8.5, i.e. a value which was not reached even in the kurkar soil. It seems not impossible that this type of chlorosis has something to do with the zinc or magnesium deficiency known to prevail in these groves, or with both. Possibly the manganese content is antagonistically raised by Mg or Zn deficiency. This can be decided only by further experiments. Meanwhile it seems important to stress that the chlorosis studied here seems to be of less specific character and of less diagnostic value than has hitherto been assumed*).

Acknowledgments. The author wishes to express his indebtedness to his teacher, Prof. H. R. Oppenheimer, on whose suggestion the present study was undertaken and to Dr. K. Mendel and the other members of the Division of Citriculture. For advice and help in connection with details of analytic procedure he is indebted to Mr. Levin, of the Division of Soil Chemistry and to the charming and helpful Mr. Kertesz M. Sc., who unfortunately lost his life during the recent War of Independence.

SUMMARY

A leaf pattern in oranges commonly regarded as characteristic of manganese deficiency has been observed on various light soils in the citrus belt of the coastal plain. The author tried to establish whether the pattern that appears on trees also showing symptoms of zinc and magnesium deficiency, was really produced by lack of manganese.

The analytical data obtained lend no support to this assumption, since leaves plucked from trees growing on sand, loamy sand and loam were found to contain 25.6, 30.2, 32.8 p.p.m. manganese, respectively (average figures pertaining to dry matter). These figures must be considered as normal. Only in decidedly alkaline kurkar

*) In a letter to Prof. H. R. Oppenheimer, dated 24/1/1949, Prof. H. D. Chapman writes: "...mild zinc deficiency patterns often closely resemble or may be indistinguishable from manganese deficiency. ...These respective deficiencies can be distinguished provided diagnosis is made on mature leaves and the entire tree is taken into account".

soil an average figure of 16.0 p.p.m. is indicative of a poor manganese supply which falls into the "poverty adjustment range". Manganese content in the Shamouti orange leaf was thus found to rise with the rising proportion of fine soil particles containing manganese, and to fall with increasing proportions of sand favouring aeration and oxidative transition of the mineral to the tetravalent form.

Spraying and injection of manganese sulphate provoked no response, confirming the impression that the symptoms are not produced by manganese deficiency. It is concluded that the type of deficiency chlorosis studied is less specific than has so far been assumed.

REFERENCES

1. BATHURST, A. C. (1943). Letter to Dr. Herzl Weizman, Rehovot, dated: Pretoria, Sept. 14th., unpublished.
2. BATHURST, A. C. (1944). Method of sampling citrus leaves for diagnosing purposes. *Farming in South Afr.* 19:329—331.
3. BRYAN, O. C. (1940). Malnutrition symptoms of citrus with practical methods of treatment. *Fla. State Dept. Agr. Bull.* (n.s.) 93, 52 pp.
4. CAMP, A. F. (1943). A résumé of feeding and spraying citrus trees from a malnutritional standpoint. *Fla. State Hort. Soc. Proc.* 56:60—79.
5. CAMP, A. F., & FUDGE, B. R. (1939). Some symptoms of citrus malnutrition in Florida. *Fla. Agr. Sta. Bull.* 335.
6. CHAPMAN, H. D., LIEBIG, G. F. Jr., & PARKER, E. R. (1939). Manganese studies on California soils and citrus leaf symptoms of deficiency. *Cal. Citrograph* 24:427, 454, 25:11, 15.
7. COLEMAN, D. R., & GILBERT, F. C. (1939). Manganese and coffein content of some teas and coffees. *Analyst* 64:726—730.
8. HAAS, A. R. C. (1932 a). Some nutritional aspects in mottle-leaf and other physiological diseases of citrus. *Hilgardia* 6:545—555.
9. HAAS, A. R. C. (1932 b). Injurious effects of manganese and iron deficiencies on the growth of citrus. *Hilgardia* 7:181—206.
10. LEVITT, E. O., & NICHOLSON, R. J. (1941 a). Manganese deficiency in citrus in New South Wales coastal districts. *Agr. Gaz. N .S. Wales* 52: 283—286.
11. LEVITT, E. C., & NICHOLSON, R. J. (1941 b). Severe manganese deficiency of citrus. *Agr. Gaz. N. S. Wales* 52:477—479.
12. LUNDEGARDH, H. (1932). Die Nährstoffaufnahme der Pflanze. G. Fischer, Jena.
13. MACY, P. (1936). The quantitative mineral nutrient requirement of plants. *Pl. Phys.* 11:749—764.
14. OBERHOLZER, P. C. J. (1946). The present status of citrus nutrition in South Africa. *Agr. Res. Inst. Pretoria Bull.* 271.
15. OPPENHEIMER, H. R. (1945). Leaf analysis of Shamouti oranges. *Pal. J. Bot., R. Ser.*, 5:86—95.

16. Oppenheimer, H. R., & Mendel, K. (1938). Problems of citrus nutrition. II. Studies on the potassium requirements of sweet lime. *Hadar* 11 :177—181; 244—248.

17. Perlberger, J. (1946). Mottle leaf in citrus trees and its correction by zinc sulphate. *Hassadeh* 26 :503—504; 547—550 (Hebrew).

18. Webber, H. J., & Batchelor, L. D. (1943, 1948). The citrus industry. Vol. 1, 2. *Univ. Calif. Press.*

19. Willard, H. H., & Greathouse, L. H. (1917). Determination of manganese by perjodate method. *J. Am. Chem. Soc.* 39 :2366—2377.

THE INFLUENCE OF PETROLEUM OILS ON THE GERMINATION OF CITRUS SEEDS AND SUBSEQUENT GROWTH OF SEEDLINGS

By Y. PATT

Division of Citriculture and Agricultural Botany, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

I. INTRODUCTION

Prior to the introduction of the non-tillage method of soil management to the citrus groves of Palestine, it has been deemed advisable to investigate whether the application of weed control oils to the soil affects germination and seedling growth of citrus.

The petroleum oils used for destruction with 15 to 75% of unsaturated and aromatic compounds, are obtained by distillation of crude oils as fractions which boil at high temperatures (9). Nevertheless their vapour pressure at ordinary temperature is high enough to allow their slow evaporation, which is accelerated by wind. MABERY, cited by GURWITCH & MOORE (6) found that 67% of a fairly heavy oil (specific weight 0.815) were lost by evaporation in one month after exposure to strong wind in a flat container. FISHER & ZERBE (4) state that even vaseline oil, exposed in a layer of 5 mm. thickness under room conditions, lost about 0.5% of its weight in ten days.

II. EXPERIMENTAL OUTLAY AND METHODS

Two open plots of orchard soil, one sand, the other red sandy loam were chosen for the experiment. They had not been manured for several years. The soils were analysed for their mechanical composition and were found to contain:
plot (1) coarse sand 10.8%, fine sand 84.8%, silt and clay 4.4%;
plot (2) coarse sand 9.4%, fine sand 77.5%, silt and clay 13.1%;

Plot (1) bordered upon cypresses and plot (2) upon pines, and the upper soil layers were mixed with dead branchlets and needles of those trees.

Weed killer No. 2 of the Shell Company (spec. weight 0.842; unsaturated and aromatic compounds 20%) was sprayed on 15.1.1947 on two sections of one of these plots at the respective rates of (a) 1.5 and (b) 0.6 litres per sq. metre, leaving a third section (c) unsprayed as control. Thereafter 25 mms. irrigation water were sprayed repeatedly on both plots by sprinkler irrigation, to facilitate the penetration of the oil to deeper layers as would also be brought about by natural rain or orchard irrigation.

On May 10th, 20 cms. wide earthenware pots were filled with soil from successive layers of each of the six subplots. The soil was taken from the following layers (depth in cm): (1) 0—2.5;

(2) 2.5—5; (3) 5—10; (4) 10—15 cms. Seven pots were filled with soil from each layer, thus obtaining a total of 168 pots which were put on saucers in an open space, between the buildings of the Agricultural Research Station. The pots were arranged at random and sown the next day with eight fresh sour orange seeds, previously disinfected by a 0.1% „Caspan" solution. No fertiliser was used.

Notes taken afterwards concerned germination of weeds and, from June onwards, of sour orange seeds. The shoot length and appearance of the seedlings was noted twice: on Aug. 4th, and on Oct. 15th, when the experiment was discontinued. On both dates the colour of each leaf was compared with standard colours of tables allowing a numerical appreciation of colour intensity, and averages for each seedlings were calculated. On Oct. 15th the leaves of each pot were collected and their total fresh weight determined. It was assumed that in this way a sufficiently clear picture of the effect of treatments on leaf production could be obtained without determination of dry weight, as was found by BENEDICT & KROFCHEK (1) in similar experiments with *Parthenium argentatum*. Cases of albinism were noted. They did not exceed one per pot and a proportion of about 2%, which PERLBERGER & REICHERT (8) consider a normal figure. After taking notes of the aerial organs on Oct. 15th, the roots of all seedlings were inspected for health and development.

III. EFFECTS ON CITRUS GERMINATION

Table I shows the effect of treatment on germination of citrus seeds in soil from the various layers, as recorded in 3 counts. The final percentage of germination (July, 21) was very uniform and not influenced by the soil, averages being 87.5; 85.0 and 88.6% for the soil from heavily sprayed (a), lightly sprayed (b) and control plots (c) respectively. The rate of germination, however, was delayed in soil of the upper layers of treatment (a); there were no significant differences between the results on the two soil types.

TABLE I.

Germination of sour orange seeds in various layers of soils superficially sprayed with oil

(Average No. of seedlings germinating from among eight seeds in 14 pots)

	Rate of oil application												Significant difference	
	1.5 litres/m²				0.6 litres/m²				Control					
Soil from layer No.:	1	2	3	4	1	2	3	4	1	2	3	4	P= 0.01	P= 0.05
Date:														
June, 8	0.2	1.2	1.4	2.1	1.1	1.3	2.0	1.5	1.5	2.4	2.4	1.8	1.3	1.0
June, 18	2.0	4.6	3.9	4.6	3.6	3.8	4.5	4.1	4.8	2.9	5.8	4.9	1.8	1.4
June, 26	3.9	6.5	6.0	6.1	5.9	5.8	5.9	5.9	6.4	6.3	6.9	6.4	1.6	1.2

The table shows that only in the uppermost layer of treatment (a) germination was clearly delayed as compared both with lower layers and with control at all dates of observation. No significant differences were found in any other case. On July 2nd, even the differences between the uppermost layer of treatment (a) and lower layers were no longer significant.

IV. EFFECT ON CITRUS SEEDLING DEVELOPMENT

(*a*) *Leaf colour*

Records of leaf colour were taken on July 20th, 24th and 30th, on Aug., 5 th and Oct., 15th. A scale of seven marks was adopted: 1=green; 2=bright green; 3=faint; 4=yellow; and three progressive degrees of "spotty" or "variegated" (5—7). By addition of average marks for the leaves of each seedling and division by the number of the latter, we obtained figures indicating the colour of the whole pot, and thence averages for treatments (series of pots). On the first three dates the colour of seedlings growing in sprayed soil was inferior to that of the control which looked green and healthy. Data recorded on Aug., 5th were submitted to an analysis of variance which led to the following conclusions:

1. On this day the properties of the soil exerted no influence on the colour.

2. Colour of leaves of seedlings growing in layers 1 and 2 of the sprayed soil of treatments (a) and (b), which apparently had absorbed the bulk of the oil, was worse than in layers 3 and 4 of these treatments and in treatment (c). The differences were significant for layers 1 and 2 of treatment (a) and for layer 1 of treatment (b). These conclusions are substantiated by table II.

TABLE II.

Influence of spraying the soil with mineral oil on leaf colour of sour orange seedlings on Aug., 5th, 1947.

(Average values from 14 pots)

	Rate of oil application												Significant difference	
	1.5 litres/m²				0.6 litres/m²				Control					
Soil from layer No.:	1	2	3	4	1	2	3	4	1	2	3	4	P= 0.01	P= 0.05
Colour Marks of leaf	27	22	18	18	21	19	16	18	15	15	15	15	5	4

The table shows lower figures, indicating better colour, in the control than in even the lower layers of the sprayed plots. The differences are slight and not significant, but might nevertheless have been produced by the physiological effects of the oil.

Owing to a general improvement of leaf colour in sprayed soil, significant differences of leaf colour were no longer found on Oct., 15th.

(*b*) *Height of seedlings and fresh weight of leaves*

Table III indicates the total height of seedlings and the total average weight of leaves per pot at the end of the experiment, as related to the depth of the soil layers, but irrespective of soil type and treatment.

TABLE III.

Influence of soil from different depths on the final height of stems and weight of leaves (irrespective of treatments and soil type), Oct., 15th, 1947.

Soil layer:	1	2	3	4	Significant difference P=0.01	Significant difference P=0.05
Average total height of seedlings per pot (cms.)	71.0	74.9	77.9	64.4	11.4	8.6
Average total fresh weight of leaves per pot (grams)	12.4	13.4	14.1	11.1	2.2	1.7

We learn from this table that height as well as leaf weight of the seedlings increase somewhat with the depth at which the soil was taken from the first to the third layer. The increase is probably a consequence of the diminishing concentration of the oil though the differences are not significant, while the decrease in the fourth layer is, in our opinion, due to diminishing concentration of nutrients. The sandy soils are known to be low in fertility and the remnants of needles and branchlets of conifers, which can be assumed to have been the chief source of nutrients of the plants, decreased definitely below a depth of 10 cms.

Table IV shows the influence of the different rates of oil application and of the soil type on the results.

The results clearly demonstrate (1) that the oil has exerted a retarding influence on both the growth in length of the stems and on the growth of the leaves; (2) that an inconsistent influence of soil texture had obtained: in treatment (a) growth was relatively better in the sand, while in the other treatments the sandy loam rendered better results.

A three-factorial analysis of variance, which is not published here, led to the conclusion that the growth retarding influence of the oil had operated in all four layers of treatment (a) and *almost* in all

layers of treatment (b). Similar results were obtained when the influence of the oil on the height was investigated by Fisher's F-test, for each seedling separately.

TABLE IV

The influence of different rates of oil application and of soil type on total height of seedlings and average weight of leaves.

	Rate of oil application						Significant difference	
	(a) 1.5 litres/m²		(b) 0.6 litres/m²		(c) Control			
Soil type:	Sand	Sandy loam	Sand	Sandy loam	Sand	Sandy loam	P= 0.01	P= 0.05
Average total height of seedlings per pot (cms.)	56.3	47.5	55.0	74.5	90.5	106.0	14.0	10.7
Average total weight of leaves per pot (grams)	9.	6.5	9.1	13.5	17.6	20.7	2.6	2.0

Since, however, the number of the seedlings in each pot was not strictly uniform, it might be argued that the different spacing might have influenced the results. To meet this objection, the correlation between the number of seedlings per pot and their height was analysed but the correlation coefficient was found insignificant. It must, therefore, be concluded that till the end of the experiment the density of spacing had not yet exerted any perceptible influence on the growth in height of the seedlings.

By comparison of the height of the seedlings on Aug., 5th and Oct., 15th it was found that the average increment in height had been 62% in treatment (a), as against 91% in (b) and 128% in (c). The increment was thus considerable even in (a), though the oil had reduced it by about one half. At the end of the experiment no significant correlation between final height and initial retardation of germination was found. The persistent differences on this date were thus found due only to retardation of the subsequent growth of the seedlings. Height and leaf weight were found closely correlated: the coefficients of this correlation were 0.92 in (a), and 0.95 in both (b) and (c). The coefficients of regression (about 4.35) were also very similar. This strengthens the impression that no important changes in size and structure of organs but essentially a general and uniform retardation of growth were provoked by the oil.

(c) Inspection of roots

Similar results were obtained by final inspection of the roots on Oct., 15th. No symptoms whatsoever of damage, no decay and

no differences in the degree of ramification were observed to have been caused by the treatments.

V. EFFECTS ON WEED GROWTH

Notes on weeds appearing in the pots were taken on June, 5th and 23rd. *Portulaca oleracea* dominated on sand and two grasses: *Echinochloa colonum* and *Digitaria sanguinalis* on the sandy loam. The abundance of these weeds was estimated by use of the scale of marks of BRAUN-BLANQUET (2) (0=lacking; 1=solitary; 2=few; 3=frequent; 4=numerous; 5=very numerous). The results are presented in table V.

TABLE V.

Abundance of weeds in the pots of the experiment

	Rate of oil application					
	1.5 litres per m²		0.6 litres per m²		Control	
Soil type:	Sand	Sandy loam	Sand	Sandy loam	Sand	Sandy loam
Layer:	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
Estimation on June 5th	0 0 1 3	0 0 0 0	0 1 3 3	0 0 1 1	4 4 4 4	5 5 5 5
Estimation on June 23rd	0 1 2 3	0 0 0 0	1 2 3 3	1 1 2 2	4 4 4 4	5 5 5 5

The table shows that until June, 5th weeds failed to germinate in all layers of the sandy loam, and in the upper 5 cms. of sand sprayed with 1.5 litres oil per sq. metre. In sand only very weak germination followed till June, 23rd. With less oil (treatment b), only solitary or few weeds appeared in soil from the two upper layers of both types, while abundance of weeds in soil from deeper layers was not more than moderate (3 marks). In the control, however, numerous to very numerous weeds were recorded.

In the interpretation of results it should be kept in mind that the species in the two soil types were different and may have a different resistance to oil. In any case, the strong inhibition of germination is remarkable.

VI. CONCLUSIONS AND DISCUSSION

Our investigation leads us to the conclusion that the inhibition of germination of citrus seeds was mainly restricted to the uppermost layer where the bulk of the oil was absorbed and operated as germination inhibitor, owing to its relatively high concentration.

The chloroplasts of leaves reflect the influence of relatively lower concentrations and therefore reacted even to the amount present in the second soil layer. Finally, the effect of oil on growth of stems and leaves was felt even in the lowest layers. The concentra-

tion of oil that exerted a growth retarding influence decreased with depth, but it must be borne in mind that the concentration of nutrients liberated from the needles and branchlets of the conifers by bacterial activity is also likely to decrease with depth. Thus an optimum curve resulted with its maximum in the third layer where the retarding influence is already small but the promotion of growth by nutrients is still relatively marked.

On the other hand the absence of typical symptoms of toxicity [as found by this author after spraying with 2, 4-D; (7)], arouses speculation whether the retardation of growth may be due not to a poisonous effect of the oil on the plasma of the cells, but rather to lack of nutrients. If the plants of the control plots reached a greater height and a higher leaf weight, this might be interpreted as a consequence of a transitory *sterilisation of the soil* interrupting in the oiled layers the liberation of bound nitrogen from the dead needles and branchlets as well as the fixation of free nitrogen from the air by *Azotobacter*. The presence of the latter organism in the soils used, though not in great numbers, has been demonstrated in our laboratory by Etinger-Tulczynska & Elze (3).

Relatively few studies on the influence of kerosene-like oils on plants growing in sprayed soils have come to our knowledge. Among the few we wish to cite the experiments of Gratch & Simcha (5) in this country. The authors investigated the germination of broad beans (*Vicia Faba*), field peas (*Pisum arvense*) and Berseem clover (*Trifolium alexandrinum*) sown after spraying a field seven times during one year with fuel oil at a rate totalling over 1000 litres per dunum (=1000 sq. metres). Germination and development of the seedlings was *better* than on a neighbouring control plot which had been cultivated by agricultural implements.

Benedict & Krofchek (1) sprayed soil in large containers where Guayule seedlings resistent to oiling were growing, five times with a mixture of Diesel and stove oil equivalent each time to 60—75 litres per dunum. Six weeks after the last spraying, the Guayule plants were removed for transplantation and the pots resown with lettuce seeds. The resulting lettuce plants were harvested after two months' growth and weighed. No significant differences were found between the weight of plants on soil sprayed with the higher or lower quantity of oil and control plants growing in unsprayed soil.

The differences of the results obtained by these authors and our own which are less favourable, can be due to (a) the different total quantity of oil; (b) the different manner of application; (c) different properties of the oils and soils; (d) different depth of penetration, and (e) possibly a higher susceptibility of the citrus seedlings to such oils.

Probably the main difference lies in the fact that the cited authors sprayed smaller doses of oil with interruptions of several weeks,

while we sprayed a total quantity which would appear sufficient for ten years, all at once, on naked soil. In doing so, our intention was to test the citrus trees under harder conditions than they would be exposed to at any time in oil sprayed groves: with a dose which never would be sprayed in practice applied to trees at their tenderest age and without a cover of weeds intercepting a large proportion of the oil before it reaches the soil surface.

If sprayed intermittently on vegetation much more oil is evaporated, while in our experiments it took about eight months after spraying before young seedlings growing in severely oiled soil overcame its adverse influence, and growth and colour became normal again. This was probably, at least in part, a consequence of partial evaporation of oil from the pots.

The author feels certain that no serious damage is to be feared for mature citrus trees, if the soil around and beneath them is sprayed intermittently with annual quantities reaching about 150 litres per dunum. We recommend waiting one and a half to two months between successive oil applications and spraying with quantities sufficient merely to cover the weeds with a thin oil laver, while overdoses penetrating into the soil should be avoided, as far as possible.

SUMMARY

Petroleum oil used in U.S.A. for the control of weeds in citrus groves was sprayed onto two plots, one sand, the other sandy loam, in heavy and very heavy single applications (600 and 1500 litres per dunum resp.). Four months later, earthenware pots were filled with soil from four successive layers (0—15 cms.) and sour orange seeds sown. The experiment continued for five further months, from May to October.

The following results were obtained:

(1) Germination of sour orange seeds was delayed increasingly by heavier doses of oil. The effect was the more pronounced the closer the soil had been to the sprayed surface. Final percentage of germination was high and uniform. Few weed seeds (*Portulaca, Echinochloa, Digitaria*) germinated with moderate oil concentrations in the soil, while high concentrations delayed germination for at least 1½ months.

(2) Leaf colour of seedlings growing in soil taken from oiled plots was yellowish, especially in soil from upper layers, but became normal before the end of the experiment.

(3) While the shape of the seedlings and especially the relation of leaf mass to height remained unaffected, growth of the shoot was delayed in the loam the more, the heavier the application of oil. No such graduation was found in sand.

(4) The roots remained healthy and no abnormal changes in their shape took place.

(5) The results suggest that control of weeds by petroleum oil will cause no serious damage to mature citrus trees in orchards, if care is taken not to distribute very heavy doses at one time.

Acknowledgements. — The author wishes to express his thanks to Dr. K. MENDEL for advice on statistical methods and to Professor H. R. OPPENHEIMER for helpful hints in the interpretation of the results and the editing of the English text.

REFERENCES

1. BENEDICT H. M., & KROFCHEK, A. W. (1946). The effect of petroleum oil herbicides on the growth of Guayule and weed seedlings. *Journ. Am. Soc. Agr.* 38(10) :882—895.
2. BRAUN-BLANQUET, J. (1928). Pflanzensoziologie. J. Springer, Berlin p. 223.
3. ETINGER-TULCZYNSKA, K., & ELZE, D. L. (1941). Occurrence and stimulation of Azotobacter in some agricultural soils of Palestine. *Pal. Journ. Bot., Reh. Ser.*, 4(1) :1—10.
4. FISHER, F., & ZERBE (1923). Brennstoffchemie S. 17.
5. GRATCH, H. & SIMCHA (1947). Weed control in orchards. *Hassadeh* 28(2—3) :97—103 (Hebrew).
6. GURWITCH, L., & MOORE, H. (1906). The scientific principles of petroleum technology. London p. 174 (quoting Mabery, 1905).
7. PATT, I. (1947). Experiments with di-chloro-phenoxyacetic acid as a herbicide. *Pal. Journ. Bot., Reh. Ser.* 6 :55—57.
8. PERLBERGER, J., & REICHERT, I. (1938). Experiments on albinism in citrus seedlings. *J.A.P. Agr. Res. Sta. Rehovot, Bull.* 24, 38 pp.
9. SHEPARD, H. H. (1945). The chemistry and toxicology of insecticides. Burgess Publ. Minn.

PROPERTIES OF THE APPLE FRUIT GROWN UNDER DIFFERENT ENVIRONMENTAL CONDITIONS

By J. Z. DAMAST*)

(With plate III).

Israel is located at the southern limits of the apple growing zone. This means that only in such localities where favourable climatic and edaphic factors coincide, can success be ensured. In this connection it seemed desirable to compare the quality of fruit grown under such widely different conditions as the Judaean mountains and the coastal plain. This seemed of particular interest since CARMON, PERLBERGER and REICH (7) during their examination of the storage life of different varieties, noted that fruit grown in the mountainous area of Israel showed a pronouncedly better keeping quality than that grown in the lowland.

Effect of climate upon fruit quality of apples was studied by SHAW (26). He found that the quality, shape and colour of apples deviate from normal to the extent that growth conditions differ from optimal ones. According to CHANDLER (8), a number of factors is concerned: heat, altitude and growth conditions, while sugar and acid content of fruit are correlated, according to CALDWELL (6), with degree of illumination i.e. number of bright sunshine hours. Storage quality is affected by both structural and physiological factors. CUMMINGS and LOMBARD (10) found that the histological structure of the pericarp, as well as the thickness of its cell walls, are involved in the fruit's resistance to pressure. The physiological basis for the understanding of storage quality of apples was laid by KIDD and coworkers (16, 17), through their researches on respiration of fruit. They stressed the importance of a sudden rise of respiration towards the end of the storage life of the fruit, marking the oncome of senescence and rapid decline. They also showed that the "climacteric", as they called this sudden rise of respiration, marked the threshold concentration of certain respiratory substrates, so that amount of substrate and rate of respiration would limit storage life. Intensity of respiration was found by HULME & SMITH (15) to be correlated with the nitrogen content of the fruit.

In the present preliminary study, in addition to morphological and anatomical observations, an attempt was made to find an explanation for the better storage quality of fruit grown at higher elevations, on the basis of chemical composition and respiratory processes.

*) Fell in the defence of his mountain home, Kfar Etzion, on May 14th, 1948. His picture is published in the Hebrew text of this issue.

DATA AND METHODS

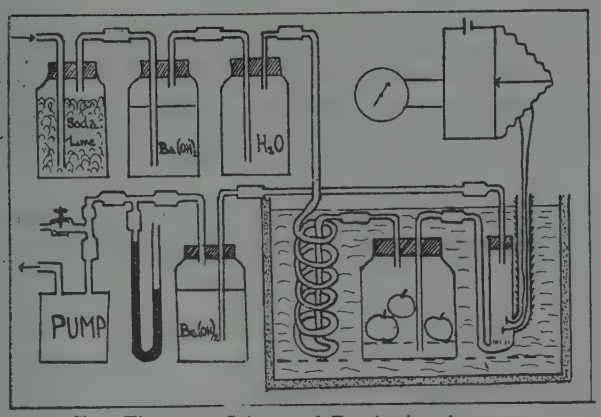
Samples of fruit were obtained from Ma'aleh-Hahamisha (800 m. above sea level), and from G'vath (Plain of Esdraelon, about 30 m. above sea level). The early varieties were procured from Ben-Shemen and Na'an in the coastal plain. These localities show the following major climatic differences: Rainfall is somewhat higher in the mountains, while relative humidity is pronouncedly lower than in the lowland (4, 5). While more dewy nights do occur in the lowland, the amount of dew deposited is less, compared to that in the mountains, (4, 5). Temperature is higher in the lowland in winter, as well as in summer, by about 4.5°C in the mean. Ashbel (3) has measured higher light intensities in the mountain area, and particularly greater intensity of ultraviolet rays, as compared with lowland conditions.

In both localities fruit was obtained from similar trees on Doucin root stock, 7—8 years old. Type of soil and irrigation practices, however, differed markedly. Lowland soil was of a medium heavy alluvial type, while in the mountains the orchard was located on a shallower *Terra Rossa* soil. In the lowlands about 500 cubic metres irrigation water were supplied per dunam (about 20 acre inches per acre), but at Ma'aleh-Hahamisha only 50 cubic metres irrigation water per dunam were added.

Most of the determinations were made on the four varieties: Red Astrachan, Peasgood Nonsuch, Delicious and Rome Beauty. Respiration was measured with the Peasgood variety only. Fruits of uniform maturity were chosen within the same lot and comparison between lots from different localities based on similarity of response to the iodine test (20). The response to the pressure test (21) was recorded and area and quality of colour (27) noted. Each sample consisted of 70 fruits.

Histological examination was carried out on sections of about 30μ width. The cuticle was peeled off and the amount of wax in it was determined, according to the procedure developed by Markley and Sando (22, 23). *Chemical constituents* were determined in the peeled and cored fruit, each sample consisting of 25 specimens. Reducing sugars were determined according to Lehmann's method (18). Hydrolysis for the determination of non-reducing sugars by standard method (1), but instead of asbestos, filter paper was used. Protein-nitrogen was determined by the Kjeldahl method (24). Ash was weighed after incineration at approximately 450°C (19).

Rate of *respiration* was measured at 30°C by means of a modification of the apparatus devised by Holdheide et al. (14). The CO_2 was determined conductometrically after absorption in a n/50 NaOH solution. The respiration train is shown in text-fig. 1. CO_2



Text-Fig. 1. — Scheme of Respiration Apparatus.

was removed from the air stream in an absorption tower with NaOH and its elimination checked by means of a $Ba(OH)_2$ tower. After bringing the air to the required temperature and humidity it was distributed to the respiration vessels, to be pumped from there through the absorption tubes for CO_2 measurement. $Ba(OH)_2$ was used to check on any possible incompleteness of absorption. A blank was run for all determinations. The air was changed at the rate of 5 litres per hour.

RESULTS

Shape and colour. — Fruit from the mountains was found to be more elongated and more conical in shape than that from the lowlands. Table I exemplifies the above statement.

TABLE I.

Effect of Elevation upon the Width/Length Ratio of Apple Fruit.

	Delicious	Rome Beauty
Mountain	5.17±0.009	1.25±0.0005
Lowlands	1.25±0.008	1.29±0.003

The shape of Delicious fruit from the mountains was shown to correspond better to the description given of this variety in the United States (13) than lowland fruit: fruit markedly ribbed, with a wide, deep, ridged cavity. Lowland fruit is more spherical, without ribs, and with rounded smooth shoulders. With the Rome Beauty variety similar differences were found. In addition core lines were noted to be more rounded in the lowland fruit, while they were of a more oblong shape in fruit from the mountains. With the earlier maturing varieties, Peasgood Nonsuch and Red Astrachan no differences were found.

Differences in colour were even more striking than those of shape. These manifested themselves in all varieties. While nearly all of the mountain fruit excelled by its vivid red colour, only a fraction of the valley fruit was coloured. Coloration not only affected a smaller fruit area, but was also less intense (see plate III, fig. 1).

TABLE II.

Effect of Growth Conditions on Colour Development.

	Red Astrachan	Peasgood	Delicious	Rome Beauty
a. Percentage of coloured fruit.				
Mountain	99	100	96	95
Lowlands	70	50	40	50
b. Area of red cheek (percentage of total fruit surface, coloured fruit only).				
Mountain	70	60	50	40
Lowlands	30	20	35	15

The russeted area was more pronounced in the valley fruit, amounting in some cases (Red Astrachan and Delicious) to 2 cm. in diameter, as compared with 0.5 cm. in case of fruit grown at high elevations.

TABLE III.

Effect of Altitude upon Chemical Composition of Apple Fruit. (*percentage of fresh weight*)

			Red Astrachan	Peasgood Nonsuch	Delicious	Rome Beauty
Dry matter		Mountain	16.6	22.0	24.2	25.7
		Lowland	12.8	19.3	14.3	13.9
Ash		M.	0.23	0.48	0.55	0.43
		L.	0.12	0.39	0.34	0.24
Titratable acid (as malic acid)		M.	1.0	0.6	0.5	0.7
		L.	1.0	0.4	0.3	0.6
Cellulose		M.	0.30	0.19	0.39	0.54
		L.	0.29	0.34	0.28	0.41
Sugar (as glucose)	reducing	M.	9.4	10.2	15.8	14.1
		L.	8.7	8.5	9.9	7.0
	di-saccharides	M.	3.2	2.7	2.6	1.4
		L.	2.5	2.4	1.1	2.5
	total	M.	12.6	12.9	18.4	15.5
		L.	11.2	10.9	11.0	9.5
Protein nitrogen		M.	0.23	0.27	0.31	0.32
		L.	0.24	0.30	0.33	0.34

Morphological differences. While no differences were noticed in thickness of cuticle, the number of small-celled hypodermal layers differed significantly (plate III, fig. 2). Fruit grown at low elevation had only 3—4 such layers, while mountain fruit showed 9—10. No

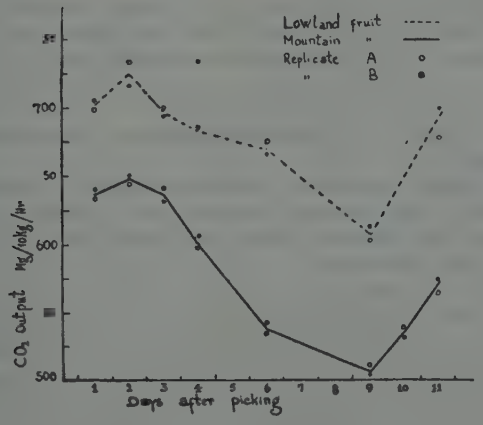
differences in size of the cells composing the pericarp were detected. Thickness of cell walls, too, did not seem to show any marked difference.

Chemical composition. Differences in chemical composition (Table III) were more pronounced with the varieties Delicious and Rome Beauty, than with the summer varieties, Red Astrachan and Peasgood Nonsuch.

Dry matter content was considerably higher in mountain fruit, especially in the late varieties. The trend shown by sugars, acids, and cellulose was similar, while just the opposite was shown by protein nitrogen.

As table III clearly shows, a definitely lower sugar content, associated with a higher protein content, was found in the lowland fruit. The reverse was true in the mountain fruit, which showed a markedly higher sugar content, associated with a low content of protein nitrogen.

Though mountain fruit was shown to be decidedly higher both in sugar and acid, there was no significant difference in the sugar-acid ratio. The difference in flavour which exists, might be at least partially explained by a greater abundance of sugars, acids and, as may be assumed, volatile esters in the mountain fruit. No differences were detected in the weight of waxy constituents. These findings corroborate our observations in the histological sections, as no difference in the thickness of the wax layer existed, between both types of fruit.



Text-Fig. 2. — Effect of Altitude upon Intensity of Respiration of Peasgood Nonsuch Apples (expressed in mgs. CO_2 per 10 kg. fresh weight and hour; date of harvest 1/8/1947).

Rate of respiration. Most interesting results were furnished by a comparison of respiratory rates between fruit from the mountain area and fruit from the Esdraelon Valley. This experiment was carried out with the Peasgood variety only. It had to be interrupted after 10 days because of fungous infection. Fig. 4 shows the difference in the relative rates of respiration. While the hourly respiration of mountain fruit amounted (in the 10 days' average) to 58.6 mg. CO_2 per kilogram, it rose with the lowland fruit to as much as 68.7 mg., a difference of about 16%.

On the whole, the intensity of respiration of Israel apples was found to be similar to that measured by Kidd et al. (17, 20), if due regard is taken to the temperature coefficient involved. While our work was carried out at a temperature of 30°C., Kidd's measurements refer to a temperature of 12—18°C. The temperature quotient (Q_{10}) of the apple fruit lies between 2.2 and 3.2 (16).

Furthermore, a close correlation exists between the nitrogen content of the fruit and its rate of respiration, as can be readily assessed from table IV.

TABLE IV.

Relation between Intensity of Respiration and Protein Content of Peasgood Apples from Different Localities.

	mgs. CO_2 /kg. hr.	protein percentage	ratio of CO_2 to protein
Esdraelon Valley	70.2	0.30	23.4
Mountain area	63.8	0.27	23.6

The amount of CO_2 respired per unit quantity of protein remains the same, both in lowland and mountain fruit.

DISCUSSION

Fruit quality is determined mainly by the following three characteristics:

1. External appearance, 2. taste and flavour, 3. storage quality. Fruit from the moutains excelled in all the above mentioned properties.

There is no unanimity about the cause of the generally better colouring in the mountains.

Arthur (2) finds that the greater intensity of ultra-violet rays plays the decisive role. Data supplied by Ashbel (3) indicating higher intensities of ultra-violet rays in the mountains of Palestine, strenghten the latter view. Overton (25) ascribes the better colouring to the higher sugar content of the cell sap, while Flint (11) attributes it to the effect of lower temperatures prevailing in mountain areas. It may be assumed that both factors are actually intercorrelated, in as much as low temperature decreasing the respiration of the sugars might be one of the contributing causes in our case.

The differences in shape are in the case of apples of minor practical importance, but seem to merit pomological and ecological interest. SHAW (27) insists on the effect of climate upon fruit shape. In our climate, apple fruits from autumn bloom when ripening in winter in the plains, have a similar shape — oblong — to fruit grown in summer in the mountains, as well as a vivid red colour. CHANDLER (9) assumes a certain influence of the climatic conditions prevailing during the first three weeks after fruit set, upon the ultimate shape of fruit. This opinion does not seem to be borne out by the fact, that differences in shape have been found by us with late maturing varieties only. Varieties ripening earlier though blossoming at the same time as later maturing apples, did not show such marked differences, while certain summer apple varieties were observed to take typical mountain form and colour when ripening in winter. Of course such differences of behaviour might be simply due to genetic causes.

Differences in taste are not easily assessed. Mere consulting the sugar acid ratio after SHAW (26) gives no explanation of the well-marked difference in taste between mountain and lowland fruit. But intensity of taste and flavour depends to a no lesser degree upon the absolute amount of constituents, sugars and acids alike. This, in addition to the observation of superior aroma supporting the assumption that mountain fruit possesses a higher percentage of odorous constituents, notably amyl esters of organic acids (9), might provide some explanation for the improved eating quality of mountain grown apples.

The differences in the amount of chemical constituents might be to some extent attributed to the better water supply in the plains, where the fruit is definitely poorer in all constituents, except protein. Higher concentrations of carbohydrates in the mountain fruit are likely to be due to an increased rate of synthesis (9) at the higher light intensities on one hand and on the other hand to slower respiration, owing to lower temperatures, especially at night. An additional cause of sugar accumulation in mountain fruit due to slower respiration may be seen in its lower protein content, as discussed below.

The well known better keeping quality of mountain fruit (7) seems to be adequately explained by our study. While the larger number of hypodermal layers seems to be instrumental in offering a better protection, our results concerning sugar content and rate of respiration, as well as the mutual relation, explain the differences in keeping quality.

The storage life of fruit is conditioned by the availability of respiratory substrate, principally sugars (12), and by the rate of respiration. Respiration rate has been found by us to be lower in the mountain fruit, while HULME (15) has shown that fruit possessing a lower N content has a lower rate of respiration. This is corroborated by our finding that respiration of fruit per unit amount of protein

was the same, regardless of provenance of the fruit. While the lower respiration rate *per se* retards break-down processes in the mountain fruit, the larger quantity of sugars represents a larger store of respiration substrate supporting a longer storage life.

The differences between apples grown in the mountains and those grown in the lowlands were less pronounced with summer varieties. This and the fact that measurements of respiration were performed on one variety only would make it appear desirable to test these findings on additional varieties.

While at least part of the morphological and physiological causes for the superior quality of Israel mountain fruits as compared with those grown in the lowlands seems thus to have been established, the explanation of the underlying factors need be incomplete, as in such regional comparisons several factors are likely to be involved. While the climatic factors are likely to play a dominating rôle, still, in addition, soil and cultural practices — while typical for the particular region — differed. This is particularly true concerning the water supply, the abundance of which in the lowlands as compared with its insufficiency in the mountains might — according to *a priori* considerations — have affected the results in a similar direction as that actually observed. On the other hand the weight of this factor is being reduced considerably by the findings of Carmon, Perlberger and Reich (7) who tested the effect of differential irrigation upon storage quality of apples in a number of field plots at low altitude. They did not find differences in storage quality with different amounts of irrigation, except that serious water shortage impaired keeping quality.

If, therefore, irrigation would have been a major factor, fruit from the mountains with their insufficient irrigation, should have shown poorer keeping quality rather than the superior keeping quality which was actually found. Although these findings would support our conclusions with respect to mountain climate as major factor in general keeping quality this does not exclude the possibility that one or the other property of the fruit might have been affected by water supply, a matter yet to be investigated.

Note. — This research was carried out in partial fulfillment of the requirement for the degree of Master of Agricultural Science at the Hebrew University School of Agriculture. It was suggested and carried out under the supervision of Dr. R. M. Samisch. This paper, representing an abstract of the thesis, was prepared by P. Spiegel.

SUMMARY

Fruits of apple varieties grown in Israel at low and high altitude were examined and the following differences established.

1. Fruit grown in the mountain area is of longer shape, tending to be ribbed and ridged. The area of red colour was found to be larger.

2. The hypodermis is thicker, but the cuticle is equal in thickness to that of fruit grown in the lowlands.

3. While the mountain fruit is richer in certain constituents, e.g. dry matter, sugar, cellulose, acid and ash, its protein content is lower.

4. Rate of respiration is lower in mountain fruit. A causal correlation between protein content and rate of respiration was established.

Intensity and quality of light, as well as temperature would seem to be the primary factors involved in these differences.

Mountain fruit, on the whole, showed a higher quality owing to its better external appearance, taste, and keeping propensity.

REFERENCES

1. Allen, F. W. (1932). Physical and chemical changes in the ripening of deciduous fruits. *Hilgardia;* 6:381—441.
2. Arthur, J. M. (1932). Red pigment production in apples by means of artificial light sources. *Contr. Boyce Thompson Inst.;* 4:1—19.
3. Ashbel, D. (1942). Solar radiation and soil temperature. Hebrew University Press Ass., Jerusalem. 125 pp. (In Hebrew).
4. Ashbel, D. (1946). Climate of Palestine an darjacent countries during 1945—46, Hassadeh Library, Tel-Aviv 32 pp. (In Hebrew).
5. Ashbel, D. (1947). Climate of Palestine and adjacent countries during 1946—47. Hassadeh Library, Tel-Aviv, 32 pp.. (In Hebrew).
6. Caldwell, J. S. (1928). Chemical composition of apple juices as affected by climatic conditions. *Jour. Agr. Res.* 36:289—365.
7. Carmon, J., Perlberger, J. & Reich, S. Experiments in storage life of apples in Palestine .(Unpublished).
8. Chandler, W. H. (1925). Fruit growing. Houghton Mifflin Co. Boston, 777 pp.
9. Chandler, W. H. (1944). Deciduous Orchards. Edit. Henry Kimpton, London, 438 pp.
10. Cummings, M. B., & Lombard, P. M. (1915). Farm apple storage. Vermont Agr. Exp. Sta. Bull. 186:130—136.
11. Flint, L. H. (1937). Note on quality of light and temperature in relation to the development of anthocyanin. *Amer. Jour. Bot.* 24:739.
12. Haynes, D., & Archbold, H. K. (1928). Chemical studies in the physiology of the apple. *Ann. Bot.* 42:965—1017.
13. Hedrick, V. P. (1922). Cyclopedia of hardy fruits. Macmillan Co. New York.
14. Holdheide, W., Huber, B. & Stocker, O. (1936). Eine Feldmethode zur Bestimmung der momentanen Assimilationsgroesse von Landpflanzen. *Ber. Deutsch. Bot. Ges.* 59:168—188.
15. Hulme, A. C. & Smith, W. H. (1937). A relationship between protein content and rate of respiration in the cell of the apple. *Dept. Sc. & Ind. Food Inv. Bd.* Rep. 1935:127—128.

16. KIDD, F. & WEST, C. (1936). Temperature and duration of life of apples. *Dep. Sc. & Ind. Food Inv. Bd. Rep.* 1935:97—102.
17. KIDD, F. & WEST, C. (1945). Respiratory activity and duration of apples. *Plant Physiol.* 20:467—504.
18. KLEIN, G. (1932). Handbuch der Pflanzenanalyse. Wien. II, 1:789 pp.
19. LOOMIS, W. E. & SHULL, C. A. (1937). Methods in plant physiology cf. pp. 137.
20. MAGNESS, J. R. & DIEHL, H. C. (1924). Physiological studies on apples in storage. *Jour. Agr. Res.* 27:1—38.
21. MAGNESS, J. R. a.o. (1926). The ripening, storage and handling of apples. *U.S.D.A. Dep. Bull.* 1406, 63 pp.
22. MARKLEY, K. S. & SANDO, C. E. (1931). Progressive changes in the wax-like coating on the surface of the apple during growth and storage. *Jour. Agr. Res.* 42:705—722.
23. MARKLEY, K. S. & SANDO, C. E. (1933). Progressive changes in the cuticle of apples during growth and storage. *Jour. Agr. Res.* 46:403—412.
24. Official and tentative methods of analysis of Ass. Agr. Chem. 1945, 932 pp.
25. OVERTON, E. (1899). Beobachtungen und Versuche ueber das Auftreten von rotem Zellsaft bei Pflanzen *Jahrb. wiss. Bot.* 33.
26. SHAW, J. K. (1911). Climatic adaptation of apple varieties. *Mass. Agr. Exp. Sta. Rep.* 23:177—245.
27. WILSON Colour Chart. (1938). The British Colour Council. Vol. I and Vol. II.

EXPLANATION OF PLATE III.

Fig. 1. — Fruit grown in the Mountains compared to Lowland fruit:
First row (horizontal): Rome Beauty — Lowland fruit.
Second row: Rome Beauty — Mountain fruit.
Third row: Delicious — Lowland fruit.
Fourth row: Delicious — Mountain fruit.

Fig. 2. — Transverse section through peripheric layers of Delicious apple fruit from Mountain (left) and Lowland (right). Note the smaller size of cells in the former.

Fig. 1.

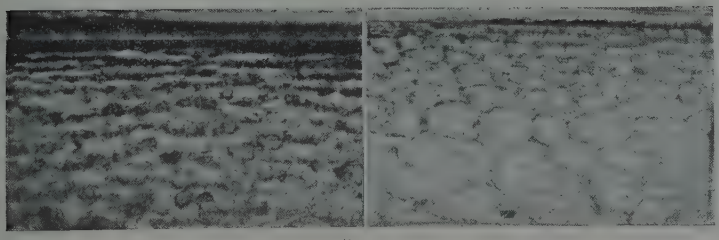


Fig. 2.

Fig. 1.

Fig. 2.

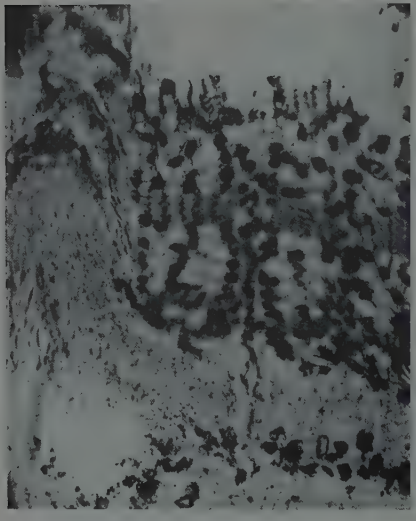


Fig. 3.

Fig. 4.

THE EFFECT OF SYNTHETIC GROWTH SUBSTANCES ON THE ROOTING OF GRAPE-VINE CUTTINGS

By LOTTE HEYMANN-HERSCHBERG*)

(With Plate IV)

A. ROOTING EXPERIMENTS

1. *Methods*

Experiments have been undertaken, in order to improve the rooting percentage of certain grape vine hybrids used as rootstocks in Palestine. These vines were: Rupestris du Lot, Chasselas × Berlandieri 41 B, and Solonis × Rupestris 216—3. Cuttings of these vines grafted with the variety Dattier de Beyrouth were treated with the following synthetic growth substances: Ortho-chlorophenoxy acetic acid (ClPhOA), β-naphthoxy acetic acid (NOA), and indole-acetic acid (IA). These were applied in not too abundant lanolin (LAIBACH; 12) in concentrations varying from 0.5 to 5 mgs. per gram (ClPhOA and NOA) and 1 mg. per gram resp. (IA). The two substances were also tested in talc (STOUTEMEYER; 20) in concentrations of 0.05, 0.5, and 5%.

The growth substances were applied either at the base or at both base and apex of the stock cuttings. The bases of other grafts were immersed for six hours in water or weak solutions of growth substances, both kept at 28° C

Afterwards, the grafts were either kept outdoors at nearly 14°C in wet sand, or indoors for 32 days (from February 3rd, 1944) at 16° to 22° C in boxes filled with wet sawdust. Subsequently the grafts which had already developed rather long roots were planted in the nursery of Miqveh Israel and cultivated, as customary (HOCHBERG; 10).

Notes were taken concerning the length of the young branches, while later on the diameter of the vines and details of their ramification were also noted. The "intensity of rooting" was defined and expressed by a scale of three marks, representing an integration of the percentage of rooted cuttings and the number and length of roots on each of them. Root length was found to vary much with soil depth, etc. and, considered alone, would therefore not be an adequate criterion.

Callus formation at the graft union was also expressed by marks from 0 to 3.

2. *Results*

(a) *The main experiments* (1944)

Owing to divergent individual responses, the results in 1944 were somewhat inconsistent (see table 1, 2) and must be considered as preliminary, at any rate where the treatment was not repeated in 1946.

---

*) Abridged translation of the main part of a Hebrew thesis, presented to the Hebrew University in 1944 for the degree of Master of Agricultural Science.

Influence on callus formation and rooting. The treatment series with the rootstock Solonis x Rupestris 216—3 were the first to strike roots. Those kept indoors were planted on March, 7th, the others on March, 13th. The 41B grafts were planted one month later, with roots still scarce and weak, while Du Lot could be planted earlier, two weeks after 216—3.

TABLE I.

Rooting of Solonis x Rupestris 216—3 cuttings grafted with Dattier de Beyrouth (1944)

Treatment*)		Place of application***)	Number of cuttings treated	Number of cuttings which formed callus	Number of cuttings which rooted	Number of roots per cutting**)	Intensity of rooting**)	Graft union**)
a) *Indoor storage*								
ClPhOA	0.5 %	I	19	19	15	6.4	2.2	1.5
„	0.1 %	I	17	17	15	4.5	1.7	1.8
„	0.05%	I	20	20	17	6.5	2.1	2.0
„	0.5 %	II	19	19	17	7.4	2.1	3.0
„	0.1 %	II	20	20	18	4.8	2.0	3.0
„	0.05%	II	19	19	16	5.8	2.5	3.0
NOA	0.5 %	I	20	20	19	3.5	1.5	2.2
„	0.05%	I	20	19	15	5.4	1.7	1.8
„	0.5 %	II	20	20	17	4.4	1.6	3.0
„	0.05%	II	19	19	14	5.8	1.9	3.0
IA	0.1 %	I	20	18	12	6.1	2.1	1.8
„	0.1	II	20	20	16	7.3	2.3	2.3
Lanolin		I	20	20	16	5.4	1.7	1.1
„		II	10	10	9	5.0	1.7	1.8
Control			16	12	12	4.5	1.5	1.0
Warm bath with ClPhOA	0.01%		10	9	9	5.1	2.1	1.0
Warm bath with tap water			10	10	10	8.3	3.4	?

*) All growth substances were applied in lanolin.

**) Average, calculated from the rooted cuttings only.

***) I means application at the basal end only, II both at the basal end and at the graft union.

TABLE I (continued)

b) *Outdoor storage*								
ClPhOA	0.5 %	I	20	20	18	7.6	2.4	1.9
„	0.1 %	I	21	21	16	4.4	1.9	2.1
„	0.05%	I	20	20	14	4.7	2.1	1.6
„	0.5 %	II	19	19	17	4.7	1.8	3.0
„	0.1 %	II	21	20	18	5.0	1.7	3.0
„	0.05%	II	20	19	18	6.5	2.3	2.4
NOA	0.5 %	I	21	21	21	6.8	2.4	3.0
„	0.05%	I	20	20	18	7.0	2.5	3.0
„	0.5 %	II	20	20	16	5.5	2.0	3.0
„	0.05%	II	21	21	21	8.5	2.5	2.4
IA	0.1 %	I	20	20	16	5.2	1.7	2.0
„	0.1 %	II	21	21	16	4.2	1.8	2.4
Lanolin		I	16	16	11	4.1	1.7	1.5
„		II	10	10	6	4.8	1.8	1.8
Control			9	9	6	3.8	1.2	1.4

Most indoor cuttings of 41B succumbed to mould after five weeks of storage. Only a few callused and still fewer rooted. Of those treated with IA and kept indoors none rooted, while the other growth substances accelerated rooting indoors relatively to outdoor grafts. Most effective were: 0.5% of ClPhOA in lanolin; 0.5 and 5% of ClPhOA in talc powder; and 0.1 per cent of NOA in lanolin. They favoured callus formation and accelerated rooting.

The growth substances increased the number of roots per cutting and the intensity of rooting. Rooting of indoor cuttings preceded that of outdoor controls by one week or more. Both heating and growth substances apparently accelerate rooting in a similar manner, and are interchangeable factors. This agrees with the conclusions of other authors (15). The stimulation of root formation by growth substances is therefore more obvious after storage in the open air than ofter heating. With 216—3, 85—90% of the treated indoor cutting rooted, as against 75—80% in the controls. Outdoors, rooting percentages were 80—100 as against 60—68, resp. With Du Lot, the most effective treatments raised the percentage from 34 to as much as 80—100, but 0.5 mgs. ClPhOA per 1 gram of lanolin yielded only 70% rooting. With 41B, the rooting percentage rose from 26 in the control to 53—85, the lower concentration of NOA in lanolin proving better than the higher. Since untreated 41B roots badly the influence of the treatments was most striking in their case. The above percentages might have increased with longer storage.

Morphological effects. Treated grafts developed a strong and knobby basal callus which was much superior to controls. With NOA the whole lower portion of the cuttings developed callus. The outer bark burst and peeled off in ribbons.

Concentrations. The lowest concentrations of NOA and of ClPhOA proved relatively ineffective. Higher concentrations of ClPhOA had a striking effect on Du Lot. IA in the concentration chosen increased rooting less than ClPhOA and NOA.

TABLE II.

Rooting of Rupestris du Lot and Chasselas x Berlandieri 41B *cuttings grafted with Dattier de Beyrouth* (1944)

Treatment*)	Number of cuttings treated	Number of cuttings which formed callus	Number of cuttings which rooted	Number of roots per cutting**)	Intensity of rooting**)	Graft union**)
a) *Rupestris Du Lot*						
ClPhOA 0.5 % (L)	15	15	14	7.5	2.3	3.0
„ 0.1 % (L)	20	20	20	6.7	2.7	2.8
„ 0.05% (L)	20	18	14	3.8	1.7	3.0
NOA 0.5 % (L)	15	15	14	4.7	1.8	2.5
„ 0.05% (L)	18	18	15	5.9	2.1	2.8
IA 0.1 % (L)	17	17	14	4.7	1.9	3.0
Lanolin	20	20	10	4.8	1.7	2.9
Control	13	12	7	2.0	1.1	2.7
ClPhOA 5 % (T)	18	17	15	3.1	1.3	2.4
„ 0.5 % (T)	18	18	13	4.8	1.9	2.7
„ 0.05% (T)	20	20	13	4.8	1.8	3.0
NOA 5 % (T)	21	21	18	6.1	2.1	3.0
„ 0.5 % (T)	20	19	17	6.7	1.5	2.7
„ 0.05% (T)	20	20	12	4.1	1.9	2.6
Talc	20	20	15	4.4	1.9	2.8
Warm bath with :						
ClPhOA 0.1 %	19	18	17	6.5	2.4	2.1
„ 0.01%	21	20	19	3.9	1.7	2.1
tap water	20	20	14	5.6	2.7	2.4
ClPhOA 0.1 %***)	20	19	13	7.0	2.2	2.4
„ 0.01%***)	20	18	15	2.4	1.2	1.8
tap water ***)	19	19	17	3.0	1.3	1.4
Control	20	18	14	3.6	1.2	2.8

*) (L) means application of the growth substance in lanolin, (T) in talc.
**) Average, calculated from the rooted cuttings only.
***) These cuttings were stored indoors, all other cutting outdoors.

TABLE II (continued)

b) *Chasselas x Berlandieri 41B*								
ClPhOA	0.5 %	(L)	15	15	12	4.8	1.8	2.1
„	0.1 %	(L)	20	20	16	6.0	2.1	2.5
„	0.05%	(L)	14	14	10	3.6	1.5	2.3
NOA	0.5 %	(L)	17	17	9	3.9	1.7	2.3
„	0.05%	(L)	14	14	12	4.8	1.8	2.8
IA	0.1 %	(L)	13	12	11	3.8	1.3	1.3
Lanolin			16	11	3	6.0	1.8	2.0
Control			19	15	5	2.8	1.0	2.0
ClPhOA	5 %	(T)	13	13	11	4.0	1.5	2.7
„	0.5 %	(T)	14	14	12	7.0	1.9	2.2
„	0.05%	(T)	16	16	9	5.3	2.0	2.6
NOA	5 %	(T)	18	17	11	3.0	1.6	2.4
„	0.5 %	(T)	20	20	16	7.7	2.1	2.4
„	0.05%	(T)	16	14	12	4.7	1.3	2.6
Warm bath with :								
ClPhOA	0.01%		19	—	7	2.6	1.1	1.2
tap water			20	—	9	2.2	1.2	1.8

Graft union, bud development. Application of growth substances at the apical cut of the rootstock favoured the fusion with the scion; 216—3 which unites poorly, responded best of all. This suggests that the application of growth substances may render wrapping of the grafts unnecessary. Treatment at the apical end in addition to application at the base improved rooting, but not to an extent that this alone would justify such treatment in nursery practice.

Application of growth substances at the base of the stock cutting did not inhibit sprouting of buds of the scion, with the exception of 41B grafts treated with ClPhOA. This finding differs from the observations of Evenari & Konis (5), who tried higher concentrations. Apical application of growth substances inhibited sprouting of buds in most cases.

Lanolin and talc as carriers. We have found talc much more convenient in practical work than lanolin. Its use saves both time and material. The effects of the powder depend, however, upon the quantity of talc which adheres to the cutting after "dipping" and are, therefore, unreliable. It seems preferable to improve adhesion of the powder by addition of some sticker material than to raise the concentration of the growth substances to possibly harmful levels.

Warm bath treatment. Immersion into warm water improved rooting of 41B and 216—3 cuttings but impaired callus formation at the basal cut. With Du Lot cuttings kept outdoors, good results were obtained with warm water or warm solutions of growth substances, but in most other cases the latter did not prove favourable. Considering the inconsistency of the results and the small number of cuttings in each treatment, no general conclusions should be drawn from these experiments.

(b) *Supplementary experiments* (1946)

Certain treatments were repeated in 1946, mainly in order to study the influence on the subsequent development of the grafts in the nursery.

Only grafts of "Muscat of Hamburg" on 41B were submitted to the following treatments either at the basal or at both the basal and the apical cut of the stock: 1 or 5 mgs of ClPhOA per 1 gram of lanolin; 10 or 50 mgs. of ClPhOA per 1 gm of talc; 1 or 5 mgs of NOA per 1 gm of lanolin; 50 mgs of NOA per 1 gm of talc; 0.5 mgs of 2,4, dichlorophenoxy acetic acid (2, 4-D) per 1 gm of lanolin; 50 mgs of 2,4-D per 1 gm of talc. The substances were mixed with lanolin or talc as described above. All grafts were stored from March 4th to 24th in a heated room where temperature fluctuated between 18° and 27°C. Rooting and callus formation were checked afterwards, as described. The grafts were planted at Miqveh Israel. Length and circumference of the young shoots were measured during the subsequent summer. The results are summarized in table 3.

Though the stock 41B had proved so obstinate in 1944 nearly all cuttings now formed a very strong callus and most of them struck small roots, while in storage. Differences in the quantity of assimilated food stored in the cuttings or genetical peculiarities of the plant material may possibly explain this differenct behaviour. HARMON (8) noted a similar inconsistency in the rooting of certain vine varieties in different years.

The callus was even larger than desirable. In nursery practice such thick callus knobs are removed before planting, in order to promote root formation at the base of the cuttings. A certain antagonism between callus and root formation is indeed borne out by the results of EVENARI & KONIS (5).

As in 1944, better rooting was obtained after the application of growth substances. Generally speaking, roots were longer and more numerous. Only 36% of the controls rooted before planting, in contrast to 70% with NOA (0.1%) and about 50% with ClPhOA, both in lanolin. ClPhOA (1%) in talc increased the percentage of rooted cuttings to 46, but the higher concentrations of either ClPhOA or NOA in talc did not improve rooting or even caused a slight retardation. Experiments with 2,4-D were now undertaken ,since this substance had recently proved excellent in similar experiments by HITCHCOCK & ZIMMERMAN (9). Though low concentrations of this very effective substance were used (0.05% in lanolin and 1% in talc), these were obviously still too high, affecting the vitality of the cuttings adversely. Rooting was reduced to percentages as low as 1—12, and callus formation was considerably hindered.

As mentioned above, special attention was payed to the development of the grafts. The results are presented in table 3.

TABLE III.

Development of vine grafts in the nursery (1946) (*Average length of the longest branches of about 25 grafts in cms.*)

Treatment*)		Place of application**)	Measurements taken in:			
			May	June	July	August
ClPhOA	0.5 % (L)	I	5.0	18.5	53.6	64.6
„	0.5 % (L)	II	3.0	8.9	40.8	57.4
„	0.1 % (L)	I	4.4	9.5	43.5	72.5
„	0.1 % (L)	II	2.9	9.7	42.8	62.5
NOA	0.1 % (L)	I	2.9	9.4	32.4	52.3
„	0.1 % (L)	II	2.4	9.4	40.1	57.5
2,4,D	0.05% (L)	I	0.0	4.8	25.6	48.6
„	0.05% (L)	II	0.0	5.0	—	—
ClPhOA	5 % (T)		2.9	11.7	38.6	58.1
„	1 % (T)		2.6	9.2	32.4	53.8
NOA	5 % (T)		1.3	4.5	20.3	50.0
2,4,D	1 % (T)		1.0	—	—	—
Control			3.0	7.1	37.0	58.8

In both experiments we find a parallelism between original intensity of rooting and subsequent growth in the nursery. No definite inhibiting effect of the treatments on bud sprouting was observed after planting, except with indoleacetic acid, which in 1944 had delayed sprouting of lateral buds, but this proved unimportant for subsequent growth. In 1946, the untreated control cuttings were among the first to sprout, while the application of ClPhOA in lanolin, NOA in lanolin, and ClPhOA (1%) in talc delayed sprouting. The inhibition of lateral bud development by growth substances is a well established fact, while the subsequent energetic growth of the treated grafts is easily explained by their stronger root systems.

The damage done to the vines by the excessive concentrations of ClPhOA and NOA in talc and the 2,4-D in lanolin and talc is in the nursery even more obvious than before planting. Therefore concentrations must not exceed optimum levels under any circumstances.

Careful selection of the plant material, as well as careful handling of the grafts affect the success decisively and may enhance the favourable influence of the growth substances.

*) (L) denotes application of the growth substance in lanolin.
(T) in talc powder.

**) I denotes application at the basal end only, II at the basal end and at the graft union.

3. *Discussion*

KORDES (11) immersed vine grafts into solutions of growth substances. The grafts rooted after 16 hours of immersion not only at the basal end but also at the graft union and further above at the scion. This is considered as undesirable. EVENARI & KONIS (5) saw negligible effects after 48 hours' immersion of vine grafts in such solutions. Cuttings without leaves absorb only very little from solutions (RAPPAPORT; 17). The application of the active substance in lanolin at the base of cuttings thus appears preferable to immersion in solutions.

AMLONG (1) immersed cuttings of *Vitis vinifera* in warm solutions of growth substances. The percentage of rooting increased with temperature up to 25°C. Obviously the temperature of the solutions, rather than their concentration, was decisive. In agreement with MOLISCH (14) who proposes temperatures of 27° to 35°C for warm bath forcing of several trees and bushes, we consider a temperature of 25°C as insufficient for our subtropical material. SCHWARZ (19) also found duration and temperature of warm baths more decisive than additional stimulants, which may inhibit growth by excessively high concentrations. Optimum conditions depended upon species and season.

In view of these studies, we consider our own negative results with warm baths as inconclusive. Optimum conditions for each variety must be found empirically since the nature of the physiological influence of warm solutions remains obscure, notwithstanding the theories by BORESCH (3, 4) and MOLISCH (14).

In the experiments of EVENARI & KONIS (5, 6) as well as in our own the union of bud and scion was strikingly accelerated by the growth substances, in contrast to negative results of FISCHNICH (7) with indoleacetic acid, which appear surprising.

B. ANATOMICAL OBSERVATIONS

Methods. Samples of the basic parts of rooting cuttings were fixed in formalin. After three weeks the samples were transferred to a 1:1 solution of glycerol and 50% alcohol. After sufficient softening they were cut into sections 15—20 microns thick. During sectioning the soft callus often parts from the relatively hard wood, even after being imbedded in paraffin. The sections were stained with the Pianeze IIIB triple stain.

Specific features of the stocks. Callus formation of the rootstocks proceeded according to the same pattern. We were likewise unable to establish anatomical peculiarities, in addition to the accepted morphological and physiological characteristics (BABO & MACH; 2, VIALA; 21).

Development of the callus. The basal callus originates essentially in the cambial region, with assistance of the inner rind and probably

the sap-wood. After the initial stage, short, wide tracheids with spiral thickenings arise as continuation of preexisting vessels. Later on, they form long, narrow strands following an erratic course (pl. IV, fig. 1) as is usual in the "Wundholz" (MAEULE; 13). Idioblasts with raphid bundles were observed in the peripheric layers of early stages. In bark calli, they form regular rows adjoining older tissues. Cells containing calcium oxalate crystals are also frequent in the bark portions of the medullary rays.

Root development. In transverse sections through the lowest portion of cuttings, we observed peripheric intumescences of wood and bark tissue produced by the cambium. Here, roots emerge from medullary rays, breaking their way through the bark, in analogy to previous findings on other species (15; 16), (cf. plate IV, fig. 2).

According to RAVAZ (18), the eruption of roots from grape vine cuttings is produced by the help of a temporary callus-like tissue, opening the passage for the young root. Suberized cells, phloem fibres, and medullary rays are said to partake in its formation, widening the space between the strands of fibres and disintegrating the peripheric cork layer. The root is assumed to replace this tissue. We feel unable to corroborate RAVAZ's findings. In pl. IV, fig. 3, a still undifferentiated root is seen originating in the cambial zone, making its way through a medullary ray of the phloem, no forerunner tissue being recognizable. Plate IV, fig. 2 shows an older root with cortex and stele. Again, there is no fore-runner tissue.

Generally speaking ,our observations confirm the accepted view that adventitious roots do no originate from the callus, but there seemed to be one possible exception of this rule (plate IV, fig. 4). In the well differentiated basal callus of one cutting we found a group of crowded small meristematic cells which may be looked upon as a typical root initial. Frequently we observed young roots puncturing the callus but originating from deeper layers.

Supplementary Note

The synthetic growth substances used in the above study were also tested on olive cuttings. With olives, they somewhat improved callus formation but failed to induce rooting. Most effective in callus production were: 0.1% of chlorophenoxy acetic acid in water, and warm baths (with tap water) at 30°C. Treatment with β-naphthoxy acetic acid in weak concentrations (0.001% and 0.0001% in water) also proved beneficial.

C. SUMMARY

Ortho chlorophenoxy acetic acid and β-naphthoxy acetic acid increase the rooting percentage of the grape-vine rootstocks Solonis x Rupestris 216—3, Chasselas x Berlandieri 41B, and Rupestris du Lot. The cuttings root earlier, developing a superior root system. If

applied at the graft union, these growth substances induce the formation of a strong connecting callus.

The effects of the above growth substances are the more striking the worse the conditions and the less is the inherent tendency towards rooting. Therefore they stand out under outdoor conditions, as compared with storage in a heated room, and are more conspicuous with 41B than with other rootstocks.

With the application of the above growth substances the nurseryman in subtropical countries no longer needs to heat grape-vine cuttings prior to planting.

Lanolin proved to be a more suitable carrier of growth substances than talc.

Treated vine grafts which root relatively early and form a well ramified root system, were also found to develop better in the nursery.

Dipping into warm water or dilute solutions of growth substances increased the rooting percentage of vine grafts in some cases.

Acknowledgement

The author wishes to express her gratitude to her teacher, Professor H. R. OPPENHEIMER, upon whose initiative and under whose supervision this investigation was carried out, for advice and help in editing. Thanks are also due to K. MENDEL, Ph.D. and Agr. Eng. HOCHBERG for valuable help and suggestions.

REFERENCES

1. AMLONG, H. U. (1938). Wuchsstoffhaltige Warmbaeder als Wurzeltreibmittel bei Stecklingen. *Ber. dtsch. bot. Ges.* 56:239—246.
2. BABO, A. von & MACH, E. (1924). Handbuch des Weinbaus. Bd. 1. Berlin.
3. BORESCH, K. (1924). Zur Analyse der fruehtreibenden Wirkung des Warmbades. I. & II. *Biochem. Z.* 153 (1924), 170 (1926). Cited by L. SCHWARZ (1933).
4. BORESCH, K. (1928). Zur Biochemie der frühtreibenden Wirkung des Warmbades. 3. *Biochem. Z.* 202 (1928). Cited by L. SCHWARZ (1933).
5. EVENARI, M., & KONIS, E. (1938). The effect of hetero-auxin on root formation by cuttings and on grafting. 1. *Pal. Jour. Bot. Jerusalem Ser.* 1:13—26.
6. EVENARI, M., KONIS, E. & ZIRKIN, D. (1938). The effect of hetero-auxin on root formation by cuttings and on grafting. 2. *Pal. Jour. Bot. Jerusalem Ser.*, 1:125—130.
7. FISCHNICH, O. (1937). Wirkstoffe und Wurzelbildung. (Foot-note). *Ang. Bot.* 19:522—530.
8. HARMON, F. N. (1943). Influence of indolebutyric acid on the rooting of grape cuttings. *Proc. Am. Soc. Hort. Sci.* 42:383—388.
9. HITCHCOCK, A. E. & ZIMMERMAN, P. W. (1942). Root-inducing activity of phenoxy compounds in relation to their structure. *Contr. Boyce Thomps. Inst.* 12:497—507.

10. Hochberg, N. (1938). Propagation of grape vines and plantation of vineyards. Tel Aviv (Hebrew).
11. Kordes, H. (1938). Bedeutung der Wuchsstoffe fuer die vegetative Vermehrung der Rebe, insbesondere fuer die Rebveredlung. *Gartenbauwiss.* 11 :545—554.
12. Laibach, F. (1935). Ueber die Ausloesung von Kallus- und Wurzelbildung durch β-Indolylessigsaeure. *Ber. dtsch. bot. Ges.* 53 :359—364.
13. Maeule, C. (1895). Der Faserverlauf im Wundholz. *Bibliotheca Botanica,* Heft 33.
14. Molisch, H. (1920). Pflanzenphysiologie als Theorie der Gaertnerei. Jena.
15. Overbeek, J. van, Gordon, S. A. & Gregory, L. E. (1946). An analysis of the function of the leaf in the process of root formation in cuttings. *Am. Jour. Bot.* 33 :100—107.
16. Priestley, J. H. & Swingle, C. F. (1929). Vegetative propagation from the standpoint of plant anatomy. *U. S. Dept. Agr. Bul.* 151, 1—98.
17. Rappaport, J. (1937). The influence of leaves and growth substances on the rooting response of cuttings. *Nat. Tijdschr.* 21 :356—359.
18. Ravaz. (1902). Porte-greffes et producteurs directs. Cited by Babo und Mach (1924).
19. Schwarz, L. (1933). Wirkung des Warmbades und einiger chemischer Baeder auf das Wurzeltreiben von Stecklingen. *Gartenbauwiss.* 8 :285—321.
20. Stoutemeyer, V. T. (1938). Talc as a carrier of substances inducing root formation in softwood cuttings. *Proc. Am. Soc. Hort. Sci.* 36 :817—822.
21. Viala, P. (1910). Ampélographie. Vol. 1. Paris.

EXPLANATION OF PLATE IV

Fig. 1. — Longitudinal section through the basal callus of a rooting vine cutting (×80). Tracheid strands, forming irregular curves and knobs.

Fig. 2. — Transverse section through the basal part of a rooting vine cutting (×70). Two young roots, developing from the cambial region, break the bark displacing medullary rays.

Fig. 3. — Transverse section through the basal part of a rooting vine cutting (×75). On the left, a young root is seen to pierce the bark.

Fig. 4. — Longitudinal section through the basal callus of a rooting vine cutting (×105). Note the group of small meristematic cells amidst differentiated tissues.

AVENA CYLINDER TEST OF TWO SYNTHETICAL GROWTH PROMOTERS

By LOTTE HEYMANN-HERSCHBERG[1])

In connection with a study undertaken in order to promote rooting of vine cuttings (3), it seemed desirable to examine the physiological activity of the growth substances used on a well studied object. Consequently, we tested the effect of β-naphthoxy acetic acid (NOA) and ortho chlorophenoxy acetic acid (ClPhOA) on the length growth of the Avena coleoptile.

As the technical outfit for Went's curvature test was not available, we first tried WENT's (7, 8) pea test, but like JOST & REISS (4) we failed to obtain satisfactory results. Even after preparation of the epicotyls of the variety "Victoria" in red light, only a certain proportion bent according to expectation.

Therefore we finally adopted THIMANN's oat cylinder test (9), using coleoptile cylinders of the selected oat strain "Uruguay" under laboratory conditions. Only coleoptiles of uniform age and size were chosen, and the first cylinder was cut beginning 2 mm. from the tip. In some experiments only one cylinder was cut from each coleoptile for the sake of uniformity. For the same purpose each cylinder was immersed — for 18 hours — into the same volume of solution, since JOST & REISS (5) have found this advisable. With these precautionary measures, individual growth differences could be effectively reduced though a certain inconsistency remained. This may be explained by fluctuations of external conditions from day to day, genetic differences of the material or the regeneration of a physiological tip after prolonged immersion. MONSELISE (6), working with a modified oat cylinder test, met with similar difficulties.

Tables I and II show the results. With both growth substances, a clear optimum curve was obtained. Optimum concentration of NOA was at 1 to 10 mg per litre water, while 10 to 100 mg of ClPhOA were required for maximal effects. Thus the former substance proved relatively more effective than the latter here as well as in our experiments with rooting of vine cuttings. It should be noted that in the former case stretching of cell walls was favoured, while in the latter cell division was stimulated.

In conclusion we wish to stress that NOA is not effective if tested with the Avena curvature test (1). This may be due to its chemical structure influencing the translocation in plant tissue. According to HAAGEN-SMIT and WENT (2) substances lacking the pyrrole ring, such as NOA, are not transported in the parenchymatic tissue, in contrast to indole acetic acid. For such substances the cylinder test is therefore much more suitable since a general and intimate contact with the cells of the growing cylinder is produced by immersion.

---

[1]) Abridged translation of the appendix of a thesis presented to the Hebrew University in 1944 for the degree of Master of Agricultural Science.

TABLE I.

The influence of β-naphthoxy acetic acid on the elongation of oat coleoptile cylinders (elongation as percentage of original length)

Date of experiment	Number of replications	Concentration of NOA (mgs per litre)							Tap water	Ind. Ac. 176 mgs per litre
		100	50	10	5	1	0,5	0,1		
10.5.44.	5	25.6	26.9	33.9	32.2	34.2	21.4	20.7	13.9	24.2
20.5.44.	5	23.8	26.4	25.5	26.6	28.5	26.9	22.3	13.9	23.8
24.5.44.	5	19.0	25.7	25.5	27.6	25.5	25.4	18.6	12.1	25.1
Average		22.8	26.3	28.3	28.8	29.4	24.6	20.5	13.3	24.4

TABLE II.

The influence of ortho-chlorophenoxy acetic acid on the elongation of oat coleoptile cylinders (elongation as percentage of original length)

Date of experiment	Number of replications	Concentration of ClPhOA (mgs per litre)						Tap water	Ind. Ac. 176 mgs per litre
		980	490	98	9,8	0,98	0,098		
4.6.44.	6	19.5	—	31.2	33.3	28.7	23.4	9.2	26.0
7.6.44.	6	14.4	18.3	26.9	25.2	21.9	18.5	9.2	30.8
8.6.44.	6	18.0	18.9	27.6	20.2	19.9	11.1	12.0	29.6
Average		17.3	18.6	28.6	26.2	23.5	17.7	10.1	28.8

REFERENCES

1. Haagen-Smit, A. J. & Went, F. W. (1935). A physiological analysis of determinating activities of growth-promoting substances. *Am. Jour. Bot.* 30 :649—654.
2. Haagen-Smit, A. J. & Went, F. W. (1935). A physiological analysis of the growth substance. *Proc. Kon. Akad. Wet. Amsterdam,* 38 :852—857.
3. Heymann-Herschberg, L. (1949). The effect of synthetic growth substances on the rooting of vine cuttings. *Pal. Jour. Bot., Rehovot Ser.,* 7. 113—123.
4. Jost, L. & Reiss, E. (1936). Zur Physiologie der Wuchstoffe. 2. *Zeitschr. f. Bot.* 30 :335—376.
5. Jost, L. & Reiss, E. (1937). Zur Physiologie der Wuchsstoffe. 3. *Zeitschr. f. Bot.* 31 :65—94.
6. Monselise, S. P. (1945). On a modification of the oat cylinder test for growth substances used to show the presence of auxin in growing citrus shoots. *Pal. Jour. Bot., Rehovot Ser.,* 5 :106—111.
7. Nicol, H. (1940). Plant growth substances. London.
8. Overbeek, J. van & Went, F. W. (1937). Mechanism and quantitative application of the pea test. *Bot. Gaz.* 99 :22—41.
9. Went, F. W. & Thimann, K. V. (1937). Phytohormones. New York.

LYSENKO'S THEORY OF THE VARIABLE GENE VIEWED IN RELATION TO THE LIFE-SPHERE SYSTEM OF FUNGUS TAXONOMY

By RICHARD FALCK, Haifa

THE CONTROVERSY CONCERNING LYSENKO's THEORY

The great success achieved by Lysenko in the theory and practice of plant and animal breeding by developing and applying Mitschurin's methods has laid the foundation for his unprecedented victory in the Moscow Academy of Sciences over followers of the hitherto accepted theories of heredity and breeding, as effected by the intervention of the government of the USSR on his behalf (cf. Discovery, vol. 2, no.11, November 1948).

A violent controversy between exponents of the Mendel-Morgan principles of heredity and the Lysenko school is now raging, in which political arguments are interwoven with scientific theories.

According to the theories expounded by Weissman and Morgan the genes transmitting hereditary trends are not in any way variable and changed characters acquired by adaptation are not inheritable. New hereditary trends are considered to arise only spontaneously, as mutations unrelated to the influence of environmental factors and to the adaptation of the organism to the latter.

Mitschurin-Lysenko's theory, on the other hand, maintains that the genes transmitting hereditary characters are variable and subject to adaptation to environmental factors. By suitable manipulation of the environment it is thus considered possible to cause the genes to acquire by adaptation desirable characteristics which are then transmitted hereditarily.

Now Weissmann and Morgan do not deny the changes induced in certain characteristics by reaction of these and their genes to external factors. They contend, however, that such reaction is strictly limited to individual variations, especially those of quantitative nature, that are apparent in the course of development; but they refuse to admit that this reaction may extend to qualitative changes in the

gene and be hereditary in nature. Adherents of this theory further deny that LYSENKO's experimental work constitutes adequate proof for his theories, and maintain that all his breeding results are explainable on the basis of the orthodox theories of heredity.

In the course of more than forty years of mycological research the present author has evolved an approach to the taxonomy of fungi in which the influence of environmental factors on the phylogenetic development of these organisms is of fundamental importance. It is the purpose of this paper to present some of our conclusions, arrived at without connection with MITSCHURIN and LYSENKO's work, and to discuss their bearing on the present controversy.

ADAPTIVE CHANGES IN THE PHYLOGENETIC DEVELOPMENT OF FUNGAL SPORANGIA

To demonstrate the variability of characters in the phylogeny of fungi we have chosen the organ most expressive in form and function, and thence most important in their taxonomy, the sporangium serving for the formation and dispersal of the reproductive cells of fungi.

Adaptation to water dispersal

The sporangium of the lowest class, the *Archimycetes,* and of the next higher class, the *Chytridiales* and the *Oomycetes,* has in our "Richtlinien des orbis-vitalen Systems" (3) been termed a "hydrosporangium" and its spores "hydrospores". These have formerly been known as zoo-sporangia and zoospores, although they bear no relation to the ciliate reproductive cells of animals. Our new term indicates that the form and function of these sporangia and spores as well as their process of formation represent a hereditary and fixed product of their interrelations with the environment they live in, viz. the water. The hydrosporangium forms spores lacking membranes but provided with motile paddling organs, the cilia, and with chemo-tactile reactivity. When mature, these are released by the hydrosporangium into the water where they are capable of active movement towards their new substrate. This is called active spore dispersal.

The hydrosporangium is thus perfected even in the simplest types of *Archimycetes* and in the lowest order of the *Phycomycetes,* the *Chytridiales.* It therefore cannot furnish us with evidence as to its phylogenetic process of development in these multiform groups, nor can this be traced in the case of the oospore which, in its life-sphere relationship, is to be considered as an organ of perpetuation and preservation.

Adaptation to air dispersal

On the other hand, taxonomists agree that the sporangium of the *Zygomycetes* is phylogenetically derived from the hydrosporangium. In our system (3) the organ serving for the formation

and dispersal of spores in the *Zygomycetes* has been termed a "geosporangium", because its structure and function is largely adapted to a terrestrial existence. It possesses a stalk which, growing at an angle to the substrate, raises the sporangium into free air. This stalk has developed from the carrier hypha of the hydrosporangium. It is differentiated into various forms which serve for the taxonomic distinction between the species indicative of the transition to the geosporangium (*Peronosporaceae*).

The geospores lack all paddling organs. But they are enveloped in a membrane which enables them to dry out without losing their viability. This facilitates their air dispersal for the infection of new terrestrial substrates. The more pronounced the capacity of the geospore to retain viability in dry air, the more is the perpetuation form of the *Zygomycetes,* the zygospore, repressed in the developmental process. Thus in the *Mucorineae,* with their geospores remaining viable in dry environments for long periods, the occurrence of zygospores is already rare and they are formed constantly only in a few species with very short-lived sporangiospores (*Sporodinia grandis*). In our system we have therefore denoted the *Zygomycetes* according to their most prevalent organ of spore formation, as the class of the *"Geosporangiomycetes"*.

The geosporangium cannot of its own disperse the spores singly nor can it equip them for independent, active dispersal as found in the hydrosporangium even of the lowest *Hydrosporangiomycetes.* In this respect formation of the geosporangium thus constitutes a retrogressive development.

In the further development of the geosporangium to the ascus of the higher fungi, as accepted by most taxonomists, the independent liberation of each spore and its active dispersal in the air is achieved. The geosporangium utilizes the delicate air current constantly occuring in the atmosphere, the temperature or convection currents. Closer definition of these currents helps to characterize the life-sphere relationships of ascus and basidium. The temperature currents run from the soil surface more or less vertically upwards. They are essentially due to insolation of the soil surface and are induced by heated soil or solids also during periods lacking direct sun radiation; even then the currents mostly suffice to carry individual spores with them into higher atmospheric layers where other currents and wind effect their horizontal dispersal.

The same temperature currents are likewise responsible for the spores being uniformly deposited over the surface of all bodies; the friction undergone by the currents when meeting such surfaces checks their motion and causes them to let the spores drop freely (just like the settling of dust in rooms).

To be effectively seized by temperature currents the spores have to be thrown for a certain distance into the air. It is thus the function

of the "throwing sporangium" or ascus to catapult each spore separately for the required distance into the open space above the ascohymenium. In this connection importance attaches to the number, shape and size of spores and their position and arrangement in the ascus. Important is further the sequence of ripening and the direction of orientation of the asci, enabling each ascus in turn to eject its spores separately and successively. These details fundamentally distinguish the ascus from the sporangium and characterize a positive phylogenetic progress.

A further phylogenetic advance and perfection is exhibited by the ascus, and thus the whole ascocarp, when in addition to the above functional relations it acquires the capacity to react to external stimuli. This capacity can clearly be demonstrated to be the cause of marked, progressive development. This refers to the fruiting bodies of the tactio-sensitive, the hydro-sensitive, and the radio-sensitive genera of *Ascomycetes* which have been described and depicted in our "Grundlinien" (3). The surfaces of tactio-sensitive *Discomycetes* react to touch; though mature, their ascospores are ejected only when the fruit is blown or brushed over, i.e. when special wind currents ensure spore dispersal in a horizontal direction as well.

The radio-sensitive genera have their fruiting bodies react to radiation. These bodies have a dark, almost sooty, surface with deep folds (*Gyromiteae*) or chambers (*Morchella*) lined closely by hymenium. Though the asci may have reached maturity, they eject spores only when the surface of the cap is irradiated and warmed by the sun. The spores discharged with only slight force are then seized by temperature currents emanating from the fruiting bodies and are thus almost all carried out of the folds and chambers. The temperature currents originating from the soil surface are incapable of effecting this, although they suffice to carry away spores actively ejected by asci or basidia from open hollows in the soil surface.

With this progressive development the *Ascomycetes* have reached their highest level of organisation where the actions of all their organs are perfectly integrated and the fruiting body assumes the character of a "precision organism".

Adaptation to other modes of dispersal

This, however, does not conclude the development process of the sporangium and ascus or of the fruiting body of the *Ascomycetes*: there is still a final, though retrogressive, stage of their development. In this last and phylogenetically youngest stage the ascus loses some of the above mentioned characteristics acquired in the preceding progressive epochs. Thus it loses its special relation to the surrounding air space, its spatial orientation and specific arrangement in the fruit and the active spore discharge connected with the osmotic pressure and elasticity of the ascus membrane. The spores gradually cease to be of definite number, size and arrangement within the

ascus. They can no longer be discharged freely into the air to be dispersed and deposited by air currents.

What has thus developed is no more an ascus and ascospore or an active hymenium, hymenospore or fruiting body, and cannot be classed with the active *Ascomycetes*. The life-sphere itself, hitherto characterized by spore dispersal through the air, has been changed fundamentally. The resultant type may best be discussed by reference to the truffles.

Though the truffle fruits still possess clearly discernible asci, hymenia and hymenophores, the latter have completely lost their functions and characteristics. Instead, partly new structural types and completely new functional characters are in evidence. According to our theory of orbis-vital systematics these fundamental changes bear a causal connection with the wholly modified life-sphere of these fungi.

The large fruiting bodies of the *Helvellaceae*, with their rich nutrient content, are most attractive to higher forest animals. Now phylogenetic development has in this respect taken diverse courses. Most of the higher fungi of forests have remained neutral. But a certain number of species show an antibiotic development of fungi who have formed toxic substances to ward off the attack of animals. In another group, on the other hand, a symbiotic relation of the fungi with animals has been established.

Only the symbiotic types, which have originated from fruits of the most highly developed group of the *Helvellaceae*, can be considered to have formed the basis for new structural and functional types. Among these the fruit of the *Tuberaceae* is one of the most impressive. Here asci and hymenium are situated within an envelope that remains closed and completely precludes any effect of air currents on spore dispersal. Moreover, the entire fruit is hidden below the surface of forest soils. It is thus protected from most animals and available only to higher mammals which are entrusted with the spore dispersal; these are attracted by strong smells produced at maturity, and they dig out and eat the fruit. The spores are provided with membranes resistant to digestive juices. In the animals' excrements the spores are returned to the forest soil where they may readily find the roots of tree suitable for yet another, mycorrhizal symbiotic relationship. According to form, function and life-sphere these fungi thus belong to a new class and a new, retrogressive course of development. In our orbis-vital system we have separated them from the *Ascomycetes* and termed them *Vescocarpiomycetes*, i.e. fungi with fruits eaten by animals. As mentioned above, the shape and formation process of asci in these fungi still clearly indicate their origin from active asci and from the highest level of ascocarp formation.

We have further demonstrated that even among the *Ascomycetes* with closed fruiting bodies the ascus does not in quite a few families persist in its active form but is subjected to fundamental phylo-

genetic changes leading retrogressively from higher to lower types. This has been exemplified by the description and re-naming of the genera *Lysascus* and *Fugascus* (2). In these fungi active spore discharge from the asci is replaced by the fruiting body's discharge of a mucous droplet carrying the spores, the haerangium.

Lysascus, though provided with a typical haerangium, still shows all the stages of development of the fruit of active *Ascomycetes* and is unquestionably derived from the latter. But in *Fugascus* ontogenetic development already follows a different course of nuclear division and the ascus membrane is hardly discernible. In these fungi a phylogenetic advance is thus effected not by specific further perfection of the mechanism for spore dispersal by air currents but by a more general adaptation to a new life-sphere.

The transmission of spores and fruits by bark borers has been rendered possibly only by such retrogressive development of the geosporangium.

Concomitant mycelial changes

Here the objection may be raised, why members of the *Sporangiomycetes* have not, at a much earlier phylogenetic stage, adopted this life-sphere relationship?

In our still unpublished monograph on *Vasomella* (1) we have demonstrated that only spores of this group of *Haerangiomycetes* are capable of germinating and freely and completely pervading the living cells of the heart wood and inner bark when applied to the cross cuts of pieces of newly felled conifers. Others members of the *Geosporangiomycetes* are incapable of effecting this, as they cannot exploit the sparingly soluble contents of this substrate for their nutrition. We thus note that in this case the mycelia of *Ascomycetes* have undergone a progressive development simultaneously with their spore-forming organs.

Another progressive development to be viewed under this aspect is that of the mycelia of the *Vescocarpiomycetes* to achieve a symbiotic relationship with the roots of certain tree species, such as the relation between true truffles and oak roots.

In some *Basidiomycetes* we witness to an even greater extent the developmental progress of mycelial functions simultaneous with, and parallel to, the step by step advances in the formation of fruiting bodies.

CONCLUSIONS

Our above examples further show that only a few limited types among the numerous families of *Ascomycetes* have been able to adapt themselves to new life spheres and to progress to new types of form and function, and thus to new classes. Certain prerequisites appear to have been indispensable for such adaptation and progress; quite probably an increased individual reactivity has facilitated a first step in this direction .

Thus, what we would call the „effect factors" of a specific new environmental life-sphere are not in themselves adequate as causal explanation for the origin of new structural and functional types of hyphal fungi. Essential for this purposes are also certain "reaction factors" of special types of organs which have mostly assumed new functional capacities through a preceding structural progress. A third prerequisite is the existence of specific "heredity factors" capable of linking the newly acquired reactivity with a material component, the gene, in a manner permitting of hereditary transmission.

Our examples lead us to the following generalizations concerning the hereditary variability of the gene under the influence of external factors*):

(a) The relative variability of the gene, i.e. its capacity to assume and lose characteristics, constitutes the natural prerequisite for the variability of characters and the acquisition of new attributes in the progressive and retrogressive course of development.

(b) The relative stability of the gene constitutes the natural prerequisite for the hereditary transmission of acquired attributes and their preservation over long phylogenetic periods.

(c) Each homologous type of organ likewise shows this dual property of relative variability and relative stability, though the latter may be far more prominent. This also applies to the gene which transmits these characteristics in the hereditary process.

Taxonomists of both the animal and plant kingdoms base themselves pre-eminently on homologous characters in considering the morphological significance of essential organs, in systematic classifications, and in phylogenetic derivations; they thus attach decisive genetical value to those genes that are practically never variable. However, it must be taken into account that analogous characters which are clearly related to environmental factors of the most recent phylogenetic period, may be hereditary or assume this property.

According to our theory of life-sphere taxonomy, the homologous characters, their gene complexes (chromosome) and genes must have newly formed at some stage of their phylogeny. Apart from their variability, we assume that genes and gene complexes thus newly form in the progressive, and are reduced in the retrogressive, course of phylogenetic development, as demonstrated in our "Grundlinien eines orbis-vitalen Systems der Fadenpilze" for the formation, transformation and reduction of structural and functional organ characteristics in the fungi of the *Ascomycetes* group.

---

*) Hereditary variability derived from the association and dissociation of genes and gene complexes is not considered here.

Their variability and their capacity for progressive and retrogressive changes within limited periods of time are thus properties which render the genes, as basic components of organised and animate beings, fundamentally distinct from the atoms, the components of inanimate matter, the constancy of whose properties is not limited in time.

Basing on the above conclusions we can now define our view concerning the LYSENKO theory of the variable gene, and seek a reply to the question: can the hereditary characteristics possessed by each species-type now in existence be brought into relation with the changes in the conditions of life as experienced and acquired by its ancestors in successive generations?

Our view has previously been expressed in the first and second part of our "Grundlinien" (3), and is in accord with MITSCHURIN's and LYSENKO's theories. Moreover, in this instance, we are also in agreement with LAMARCK. We have found that in the organisms we studied the qualitative and — we add — the quantitative hereditary changes experienced in the march of generations have depended on changes in the life sphere; the extent of this dependence bears relation to the organisational level of the organism and its adaptational potentialities. The more useful such adaptations prove for the organism concerned, the more favourable their influence on the further development of the species, the richer the resultant variety of forms, and the deeper the hereditary fixation. The persistence of adaptational factors has rendered possible the persistence of types of form and function over long phylogenetic periods.

We are quite aware of the fact that the examples quoted here are not, in themselves, exhaustive proof for all that is implied in our hypotheses. Further evidence is now in the course of publication. Thus the third part of our „Grundlinien" deals with the course of caryological development and its significance for life-sphere systematics, showing how far a single environmental factor in securing the survival of the species affects decisively not only the specific forms and functions of the fruiting organs but also the developmental process of their nuclei.

Acknowledgment. The author is indebted to J. PALTI B.Sc., the editorial secretary of the Palestine Journal of Botany, Rehovot Series, for the translation of this paper and for his constructive and helpful comments.

SUMMARY

The theory of MITSCHURIN-LYSENKO, that genes transmitting hereditary factors are subject to adaptation to the environment, is considered in the light of the author's experience in more than forty years of mycological research.

In the course of their phylogenetic development various fungi have variously adapted their sporangia to ensure the most efficient

spore dispersal either by water (hydrosporangium of the *Archimycetes, Chytridiales* and *Oomycetes*) or by air (geosporangium of the *Zygomycetes*) or by other agencies (e.g. by animals in the *Vescocarpiomycetes*).

Certain changes in the mycelia of some fungi have taken place simultaneously with and parallel to the adaptive changes in their sporangia.

To explain these and other observations the hypothesis is advanced that each homologous type of organ and each gene possess the dual properties of relative stability and relative variability, the latter affording the capacity to assume and lose characteristics, and the former providing the natural prerequisite for hereditary transmission. These conclusions are essentially in accord with MITSCHURIN-LYSENKO's theory of the variable gene.

REFERENCES

1. FALCK, R. & FALCK, O. (1937). Die Vasomella-Blaeue des Coniferenholzes. Ready for printing.
2. FALCK, R., & FALCK, O. (1947). A new class of Ascomycetales. A contribution to the orbis vitae system of fungi. — *Pal. Journ. Bot., Rehovot Ser.*, 6 :89—106.
3. FALCK, R. (1948). Grundlinien eines orbis-vitalen Systems der Fadenpilze. I und II. Amsterdam, 84 pp.

Dedicated to Sir Allan Cunningham, the last High Commissioner of Palestine

A RUST DISEASE OF ALEPPO PINES IN PALESTINE

By I. REICHERT and MATILDA CHORIN
Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot, Israel

(With plate V)

I. INTRODUCTION

The credit of first observing rust on Aleppo pines (*Pinus halepensis*) in Palestine must go to Sir Allan Cunningham who noted symptoms of the disease while inspecting a government pine nursery in the Hebron district during his tenure of the office of High Commissioner of Palestine, in 1946.

The disease was on closer examination revealed to be the *Peridermium stage* of a rust (plate V, fig. 1). This had neither previously been collected in Palestine in the 25 years of our phytopathological work nor had it been observed by the staff of the government department of forests. Nevertheless we are inclined to think that the disease is not a newcomer to Palestine, but has been present for some time, while the exceptionally cool and rainy weather prevailing in spring 1946 may have afforded it a first opportunity for an epiphytotic outbreak.

The assumption that the local occurrence of this rust is not new is supported by the collection of its secondary stage on various hosts in Palestine. The uredo stage of a *Coleosporium* known in other countries to be connected with needle rust of pines has been collected here many years ago on various *Compositae*, and the occurrence of the *Peridermium* stage on pines somewhere in the country was therefore highly probable. Moreover, needle rust of Aleppo pines has long been known to occur in other Mediterranean countries (8).

We are obliged to Mr. Amihood Goor, formerly Acting Conservator of Forests of the Mandatory Government of Palestine, for his help in tracing the disease in various parts of Southern Palestine.

II. THE DISEASE

Symptoms and development on pines

The rust develops in early spring on the needles especially of young trees. Infection may be thought to take place during the winter months from the inoculum derived from the alternate hosts. Infection of the young needles results in the appearance of small, orange-yellow lesions. These mark the first of the four stages of this compound rust disease that develops two stages on pines and two on various *Compositae*. These lesions may later darken and become more prominent; they harbour under their cortex the pycnia known to fulfil a sexual function in the life-cycle of rusts. The pycnia are

filled with minute spores. One or two months later there appear, near the first lesions or elsewhere on the needles, whitish blister-like eruptions that represent the *Peridermium stage* (plate V, fig. 1). The blisters are filled with aeciospores arranged in chains (plate V, fig. 2). When eruption of these blisters takes place in spring, the aeciospores infect the *Compositae* serving as alternate hosts but are unable to infect pine needles.

The infected needles gradually dry but persist on the tree for a long period before they are shed. Severely affected trees may thus either have their twigs covered by dry needles or these may have shed and the twigs remain bare.

Alternate hosts

Three plants have so far been found in Palestine to bear rust stages that are associated with pine rust, viz. *Senecio vernalis, Inula viscosa,* and *I. graveolens.* As is well known, the formation of uredospores on these hosts is succeeded by that of teliospores; the latter give rise to sporidia which, in their turn, induce infection on pine needles, thus completing the life cycle.

III. THE PERIDERIUM STAGE

Description of the fungus

The *Peridermium* causing needle rust of Aleppo pine in Palestine may be described as follows:

P y c n i a amphigenous, oblong, single or sometimes coalescing to long rows; at first coloured yellow, later orange, and finally brown; slightly raised, 0.5—1 mm. long, 0.5 mm. wide. A e c i a oblong, amphigenous, mostly located on the lower surface, 1—4 mm. long, 0.5—2 mm. wide (plate V, fig. 2). P e r i d i u m blister-like, thin, fragile, rupturing irregularly. composed of one cell layer with a thinner inner wall. Cells quadrangular in transverse section, more or less elongated, irregular, walls verruculose, 3—4.5μ thick. A e c i d i o s p o r e s oblong or oval, 21—51μ long, 15—27μ broad, sometimes roundish; walls verruculose, bearing tubercles except at certain parts that are smooth, 3—4.5μ thick with the tubercles, tubercles 1.5—2.5μ thick; distance between tubercles 1.5—2.5μ (plate V, fig. 3). The measurements of 100 spores were as follows:

length in μ:	21	24	27	30	33	36	39	51
number of spores:	3	5	26	32	15	12	4	3
width in μ:	15	18	21	24	27			
number of spores:	6	11	41	33	9			

Occurrence

We found the disease in Wad-al-Kuf, El-Rusheni and Allar in the Hebron district, 630—675 metres above sea level, and in Bab-el-Wad, on the Jerusalem-Tel Aviv highway, 575 metres above sea level,

but not on pines growing near the latter locality at Hartuv (Artuf) at only 200 metres above sea level.

The Western side of the trees was severely affected by the rust; this side is exposed to winds from the Mediterranean Sea, and dew may long persist on its leaves in the morning. On the other hand, the eastern side of the trees was almost free from disease or only very slightly affected, being exposed to the dry and hot spells of the Judean desert and with the dew dried early on its leaves by the morning sun. Small nurseries of *Pinus pinea* and *P. canariensis* in the above localities were free from rust.

Taxonomy

The above morphological description does not permit an accurate taxonomic determination of this *Peridermium*. According to FISCHER (1) and KLEBAHN (5) the taxonomic criterion should be the experimentally established connection between this rust stage and that on the aecial host. Pending such experiments we are unable to settle the question. If a connection should prove to exist between our pine rust and the aecial stage observed on *Senecio*, the species should according to the above authors be referred to *Peridermium oblongisporium* Fuckel, but in the case of its connection with the aecial stage on *Inula* sp. the rust would belong to *P. Klebahni* Fisch.

Morphological characteristics alone cannot decide the issue. The descriptions given by FISCHER (1) and KLEBAHN (5) for *P. oblongisporium* and *P. Klebahni*, respectively, coincide closely. There is only one difference mentioned by FISCHER, but not by KLEBAHN, for *P. Klebahni*:

„Auf einem Laengsstreifen der Spore sind die Staebchen kuerzer und miteinander verschmolzen, so dass eine glatte, resp. feinpunktierte Oberflaechenpartie entsteht".

As our *Peridermium* rust possessed this feature, it might belong to *P. Klebahni*. However, this characteristic appears hardly to be constant, otherwise KLEBAHN would not have omitted it in his description. Moreover, JORSTAD (2) found the same feature on a *P. oblongisporium* collected in Kamtchatka where species of *Senecio* and *Inula* have been affected by the secondary stage of the rust. We therefore prefer to leave the exact taxonomic position of our Aleppo pine rust unsettled, to assume that both the above species may be present, and to refer meanwhile to this rust as *Peridermium* sp.

IV. THE COLEOSPORIUM STAGE

Description of the fungi

As stated above, species of *Senecio* and *Inula*, both belonging to the *Compositae*, were found to bear rust stages that may be connected with Aleppo pine rust, and these stages constitute criteria for the taxonomy of the rust. Only uredospores have been observed on the alternate hosts. These spores were arranged in the chains typical of the genus *Coleosporium*. According to the accepted taxonomy, the species of *Coleosporium* on *Senecio* and *Inula* are distinct from each

other and belong to *C. senecionis* (Schum.) Vries and *C. inulae* (Kunze) Ed. Fischer, respectively. A comparison of morphological features of the uredinia of these two species as found in Palestine with the descriptions published abroad (1, 5) shows close agreement. The uredospores on these species may be described as follows:

Coleosporium senecionis (Schum.) Fries.

Uredia hypophyllous, bright, sometimes orange yellow; at times also found on leaf stalks; spores borne in short chains, oval, ellipsoid or angular, 18—27.5μ long, 12—30μ wide; wall colourless, 1.75—2.5μ thick with the tubercles; tubercles 0.45—1.2μ thick, distance between tubercles 1—1.μ (plate V, fig. 4). The measurements of 100 spores were :

length in μ:	18	21	24	27	30	33	47.5
number of spores:	11	27	27	23	9	1	2
width in μ:	12	15	18	21	24	27	30
number of spores:	2	24	36	16	9	9	4

Coleosporium inulae (Kunze) Ed. Fischer

Uredia hypophyllous, orange-yellowish, in groups and coalescing, sometimes single, about 0.5 mm. in diameter; spores borne in short chains, oval, globoid, ellipsoid, very seldom angular, 25—36.1μ long, 18—27μ wide; wall colourless, verruculose, about 3μ thick with the tubercles, tubercles 0.85—2μ thick, distance between tubercles 1—1.5μ (plate V, fig. 5). The meaasurements of 100 spores were:

length in μ:	25	27	28	30	33	34	36
number of spores:	4	18	2	26	44	1	5
width in μ:	18	19	21	23	24	25	27
number of spores:	23	2	48	1	21	1	4

Occurrence

Coleosporium senecionis was collected on *Senecio vernalis* W.K. v.*carnosus* Post in the dunes of Gaza, near the Mediterranean shore, on 3.5.1924 by N. Naftolsky.

Coleosporium inulae was collected by N. Naftolsky on *Inula viscosa* (L.) Ait. at Athlit, at the foot of the Carmel range, on 26.6.23; at Motsa near Jerusalem, 800 metres above sea level, on 12.12.24; and at Petah Tiqva, in the central coastal plain, near the sea shore, on 11.6.26.

Dr. Rayss (6) has determined material collected at Beth-Hakerem, near Jerusalem, on 3.11.1935 on *Inula graveolens* (L) Boiss. as *C. inulae*. Dr. St. Rouppertowa (7) has collected *C. inulae* on *Inula graveolens* (L.) on 21.6.44 at Nazareth.

Taxonomy

KLEBAHN (5) has emphasized the morphological resemblance between the species of *Coleosporium*. Though we think that a thorough comparison of all the species may yet reveal certain differences that could serve as differential criteria, this work still remains to be done.

We have compared the characters we observed on the spores of the two species of *Coleosporium* with those originally described by FISCHER (1) and KLEBAHN (5). FISCHER found a pronounced difference in the width of uredospores of *C. senecionis* (14—17μ) and of *C. inulae* (18—21μ). Our data tend to confirm this view, as they showed the uredospore width to range from 12—30μ (most frequently 15—21μ) in *C. senecionis* and from 18—27μ (most frequently 18—24μ) in *C. inulae*. JORSTAD (2) found the corresponding value for *C. senecionis* in Kamchatka to be 17—24μ.

As regards the shape of the spore, FISCHER differentiates between the "oblong" spore of *C. senecionis* and the "ellipsoid" spore of *C. inulae*. KLEBAHN, on the other hand, considers the spores of *C. senecionis* to be much more oblong than those of *C. inulae*. We failed to observe any difference between the spores of the two species which we both described as oval or ellipsoid.

The spore wall of *C. senecionis* is described by FISCHER as "maessig dick", as against that of *C. inulae* which is defined as "dünn". KLEBAHN more or less agrees on this point, stating that the spore wall of *C. senecionis* may be up to 2μ thick, that of *C. inulae* up to 1.5μ only. Our observations, however, showed the reverse, namely, that the spore wall in *C. inulae* is slightly thicker (3μ) than that of *C. senecionis* (1.75—2.5μ).

Spore tubercles were observed only by KLEBAHN (5). He denoted the tubercles of *C. senecionis* as "feinwarzig" — apparently too small to be measured — while those of *C. inulae* appeared thicker and are stated to be 1μ thick. Our observations confirmed this difference, as the tubercles of *C. senecionis* measured 0.45—1.3μ as against 0.75—2.5μ in *C. inulae*.

Comparison of all these data shows that there are certain limited morphological differences between these two species. However, only a thorough comparison of material collected from various hosts in various countries and habitats can establish whether or not these distinctions are constant and may be used to characterize the two species.

V. DISCUSSION

KLEBAHN (4) and FISCHER (1) have emphasized the importance of the surrounding vegetation for the development of the various rusts. They indicated that diplontic hosts mostly occur in the vicinity of the haplontic host. JORSTAD (3) even goes so far as to exclude one species, *Tussilago*, though observed to bear stages of rust, from the

list of hosts possibly connected with the secondary stage of pine rust, solely on the grounds that it "is no regular inhabitant of pine land". The observations made in Palestine show that this cannot be considered a general rule. We observed the secondary stage of *C. senecionis* in Gaza, a half-desert location far removed from pine stands and with a climate certainly unfavourable for the needle rust. As regards *C. inulae,* secondary stages were likewise found in Petah-Tiqva far from any infected pine stands.

As mentioned above, we found *Pinus Pinea* resistant to the *Peridermium* rust even where *P. halepensis* was severely affected. On the other hand, Trotter (8) indicates *P. Pinea* as a primary host for *Peridermium oblongisporium.* As *Pinus Pinea* grows in Palestine in some regions representing its ecological minimum, its resistance to the rust there may constitute yet another case of a host resisting disease under adverse growing conditions better than under conditions conducive to thriving growth. . .

The damage caused by the pine-needle rust, as indicated earlier, is not uniform and depends on the weather prevailing in spring. As the disease requires high humidity for its development, the hot khamseen winds of the spring season will generally subdue it. Though occasionally harmful, the disease is therefore not to be considered a major danger to the pine stands of Palestine.

Our observations have shown that only on slopes with western and north-western exposure may the disease assume serious proportions. It would seem, therefore that easterly slopes are preferable for the planting of Aleppo pine trees.

Only an accurate study of the habitat and distribution of the diplontic host may reveal whether the needle rust of pines could be controlled by eradication of secondary hosts.

SUMMARY

A rust was first observed on the needles of *Pinus halepensis* in Palestine in 1946. This was found to belong to a species of *Peridermium. Coleosporium* stages that may be associated wit hthe pine rust have so far been found here on *Senecio vernalis, Inula viscosa* and *I. graveolens.*

The symptoms and development of the rust on pines is described.

A detailed description is given of the *Peridermium* fungus and its occurrence in Palestine. A discussion of the taxonomic position of this fungus led to the conclusion that this cannot be definitely settled on the available evidence.

The *Coleosporium* fungi collected on the above hosts, and their occurrence and taxonomy are described. It is concluded that they may belong to two distinct species, *C. senecionis* and *C. inulae,* but this requires confirmation.

The collections made in Palestine appear to indicate that the hosts harbouring the diplontic and the haplontic stages of this rust may occur in localities fairly wide apart and diverging widely in their climatic conditions.

The pine rust is considered a potential danger only in exceptional years. As the disease is most serious on slopes with western and north-western exposure, these slopes should, if possible, be avoided in planting *Pinus halepensis*.

...

REFERENCES

1. Fischer, E. (1904). Die Uredineeen der Schweiz. *Beitr. z. Kryptogamenflora d. Schweiz.* II, 2.
2. Jorstad, I. (1933). A study of Kamchatka Uredinales. — *Skr. utg. av det Norske Vidensk. Akad. i. Oslo I. Mat. Nat. Kl. No.* 9, 183 *pp.*
3. Jorstad, I. (1940). Uredinales of Northern Norway. — *Skr. utg. av det Norske Vidensk. Akad. Oslo. I. Mat. Nat. Kl. No.* 6, 145, *pp.*
4. Klebahn, H. (1904). Die wirtswechselnden Rostpilze. *Berlin*, 447 *pp.*
5. Klebahn, H. (1914). Uredineen. Kryptogamenflora der Mark Brandenburg Va (Pilze III) *p.* 69—904.
6. Rayss, T. (1939). Contributions à la connaissance des Uredinées de Palestine. — *Extr. de Hommage au Prof. E. C. Teodoresco, Bucuresti*, 13 *pp.*
7. Stec-Rouppertowa, W. (1944). Przyczynek do znajamosci mykoflory Palestyny. *Repr. Przyroda*, 7 *pp.*
8. Trotter, A. (1908). Uredinales. Flora Cryptogama Italica I. — *Fasc.* 4: 1—144, Rocca S. Casciano.

EXPLANATION OF PLATE V.

Fig. 1. — *Peridermium* stage of rust on pine needles (×2).
Fig. 2. — The same. Longitudinal section through blister with aeciospores.
Fig. 3. — The same. Aeciospores (×800).
Fig. 4. — Uredospores of *Coleosporium Senecionis*.
Fig. 5. — Uredospores of *Coleosporium Inulae* (×750).

A DISEASE ON GREEN SWEET PEPPER FRUITS CAUSED BY *BACILLUS POLYMYXA*

By ZAFRIRA VOLCANI

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

(With plate VI)

I. INTRODUCTION

The presence of spots on sweet pepper fruits has often been recorded in Palestine. They are mainly caused by sun scald. In August, 1947, a spot disease of sweet green pepper fruits has for the first time been found in Palestine, or elsewhere for that matter, to be caused by a spore-forming bacterium.

A short account including the description of the disease and evidence that it was caused by a spore-forming bacterium has been given elsewhere (18).

This paper is to give a short description of the organism, and a more extensive account of the investigations carried out to prove and test its pathogenicity on pepper and several other plants. It includes also an account of plant diseases caused by spore-bearing bacteria.

II. OCCURRENCE OF THE DISEASE AND DESCRIPTION OF THE LESIONS

Samples of green sweet pepper (*Capsicum annuum*) fruits of the "Queen Yellow" variety and from local seeds, all bearing a few conspicuous spots, were brought to the laboratory for examination

They were collected at Hatsor in the South and at Nablus and surroundings in the centre of the country on the 1.9.1947 and the 12.9.1947, respectively, from plots under overhead irrigation. The incidence of the disease was moderately severe, and in order to save the unaffected fruits they were picked over a shorter period than usual. The majority of the lesions appeared as slightly sunken, light brown to grey, soft spots, 8—12 mm in diameter with quite definite margins where the vessels appeared as distinct dark-brown threads crossing its length and breadth. In some cases, however, the lesions appeared as dry, light-brown sunken spots, revealing the same dark-brown network of vessels. The number of spots on each fruit varied from one or two to five (plate VI, fig. 1). In all cases, the epicarp as well as the endocarp of the fruits was affected.

Free hand sections stained by CLAUDIUS' method (16) revealed bacteria in the epithelial and parenchyma cells of infected parts, but none were observed in the vessels proper.

A spore-bearing bacterium was isolated in pure culture on potato glucose agar from the lesions of the fruits brought from the South and the centre of the country, respectively. The results of the examination of both organisms have shown that they were identical.

III. METHODS

(1) Staining. CLAUDIUS' method (16) for staining bacteria in tissue was used. The following staining methods for the identification of the organism were used: a) Gram stain of the organism in culture (13). b) FISHER and CONN's method for flagella stain (13). c) HISS' method for capsule staining (15). d) SCHAFFER and FULTON's modification of WIRTZ's method for spore staining (13).

(2) For the identification of the volatile acids, the Silica Gel Partition Chromatogram method (7) was used. 500 cc. of yeast broth plus 2% of glucose with chalk and without chalk in one litre flasks were inoculated with the organism and kept at 37°C for 7 days. The acids were then estimated from the flasks without chalk, and the acetone from the flasks which contained chalk.

(3) Isolation of organism. Pure cultures were isolated from infected parts on potato glucose agar of pH 7 at 30°C. The method of isolation was as follows: Pieces of infected parts of the fruit, after being washed in tap water, were immersed in 95% alcohol for 5 seconds, then covered with 1:1000 sublimate for ½—1 minute, washed twice with sterile water for 4 minutes and transferred (a) to a Petri-dish containing media, (b) to a sterile mortar. The material was then crushed thoroughly with a pestle, and about 5 cc of nutrient broth was added to the pulp, and mixed thoroughly. The mortar was then covered with a sterile towel and was allowed to stand for about one hour. A loopful of this broth extract was spread over the surface of a potato glucose agar plate.

(4) Morphological observation and physiological tests. The morphological observation and physiological tests were carried out at a temperature of 30 and 37°C, with cultures which were (a) picked from a single colony, and spread

on potato dextrose agar slope, (b) inoculated on potato dextrose agar slope from a single colony arising from a 48 hours old nutrient broth culture, streaked onto agar, after being heated for 10 minutes at 85—90°C. The organism was measured in 24 hours' old cultures at 30°C stained by GRAM's method. The spores were measured in 48 hours' old cultures at 30°C.

(5) Infection experiments. The fruits were pricked with a needle: (a) Through drops of sterile distilled water suspension of a non-pasteurised culture of the organism; (b) Through drops of sterile distilled water suspension of a pasteurised culture of the organism; (c) By applying drops of the suspensions of the organism without pricking. In all these cases the fruits were kept in bell-jars in which humidity was kept up by introducing small beakers filled with distilled water at 28—30°C. In a second series of infection experiments, the fruits were pricked with a needle; (d) Through drops of sterile distilled water suspensions of a pasteurised and non-pasteurised culture of the organism. The wounds were then covered with vaseline or paraffin, and the fruits kept in stoppered jars with water at 30 and 37°C. There were two fruits in each jar. To avoid the contact with water, the fruits were supported on small beakers; (e) Slices of the various vegetables were smeared with a suspension of a pasteurised, and a non-pasteurised culture, and kept in Petri-dishes with plenty of water and without water at 30° and 37°C. The same treatments were also applied to the control specimens, but sterile distilled water was used instead of the suspension of the organism.

Inoculation of leaves was carried out as follows: (f) By scratching with a sterile needle the upper and lower surface of the leaves through drops of a sterile distilled water suspension of a pasteurised and a non-pasteurised culture of the organism; (g) By spraying the leaves with the same suspensions of the organism. The branches bearing the leaves were put in jars with tap water which were kept in bell-jars at 30° and 37°C. The same treatment was also applied to the control specimens, but sterile distilled water was used instead of the suspension of the organism.

Inoculation of fruits attached to the plant was carried out (h) By pricking the fruits through drops of a suspension of pasteurised and non-pasteurised culture of the organism. The wounds were then covered with paraffin and the fruits enclosed in cellophane bags. The plants were kept in a glass-house at a temperature which varied from 18—20°C at night to 37—38°C during the hottest hours of the day, and also at constant temperatures of 30°C and 37°C, respectively. The same treatment was applied to the control specimens but sterile distilled water was used instead of the suspensions of the organism.

IV. DESCRIPTION OF THE ORGANISM.

24 hours old culture grown on potato dextrose agar at 30°C., Gram stain: rods: 0.5 to 0.85 by 2.21 to 4.0 microns, occurring singly and in pairs. Motile by means of numerous peritrichous flagella; Gram positive when taken from the upper portion of a nutrient agar slope, Gram negative when taken from the bottom: Gram positive in milk but always Gram negative in any medium containing dextrose. Capsulated. Spores central, excentric or sub-

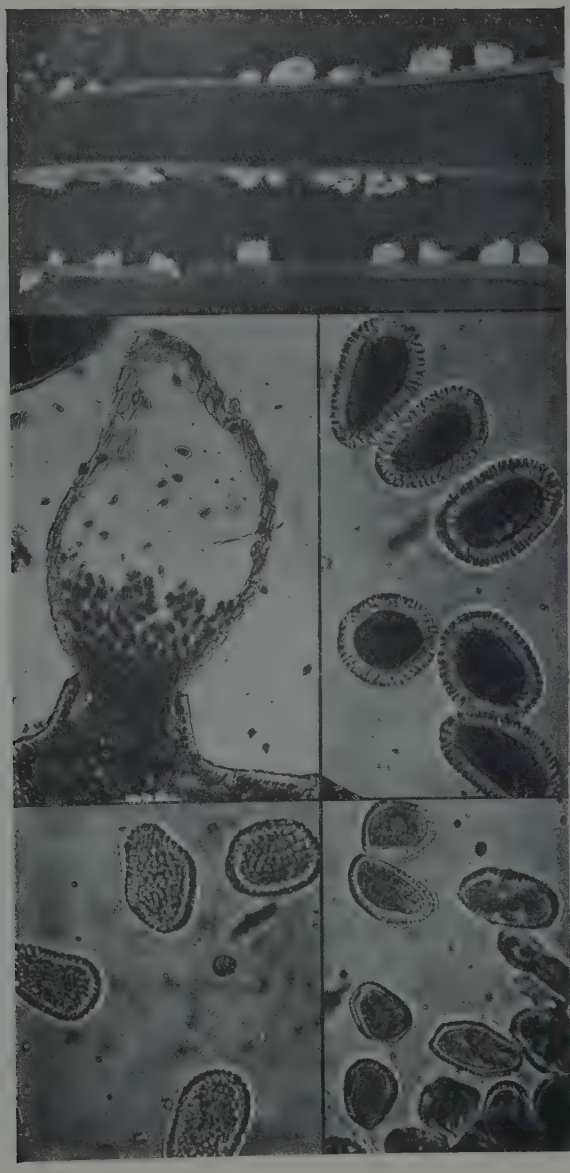


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

I. REICHERT & M. CHORIN — RUST OF ALEPPO PINES

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

ZAFRIRA VOLCANI — PEPPER FRUIT DISEASE

terminal, longer than wide; breadth in the middle 1.7 microns, length 2.04 microns. Polar germination of spores. Sporangia pointed at the ends, breadth in the middle 1.9 microns, length 3.6 microns, aerobe and facultative anaerobe. Optimum growth at 37°C., maximum temperature 50°C., minimum temperature 14—16°C. Spores do not germinate after being heated 10 to 20 minutes at 100°C temperature, but they withstand five minutes in boiling water.

Potato glucose agar colonies. — 48 hours old, circular, glistening, jelly-like colonies, entire or slightly undulate margin, granular, convex with a flat halo, cream with a slight brownish tinge. Colonies are circular with narrow distinct white margins, grey — white in its inner part when seen through the back of the Petri-dish.

The medium was unchanged in colour, and there was a slight fruity odour.

Nutrient agar colonies. — Circular, granular, glistening, cream-white, almost flat, slightly undulate margin.

Potato-glucose agar slant. — Profuse growth, glistening, gummy, granular, cream with a slight brownish tinge, slight formation of gas.

Agar slant. — Thin growth, glistening, cream-white.

Potato glucose agar streak. — echinulate.

Nutrient agar streak. — bead.

Potato glucose agar stab. — Good growth all along the stab, echinulate, slight gas formation.

Broth. — slightly turbid at first, then clears, and a slight sediment is formed at the bottom of the tube, no pellicle was observed.

Gelatine. — Rapid liquefaction — within 48 hours after inoculation.

Starch agar. — hydrolysed.

Purple milk — Coagulation within 48 hours after inoculation at 37°C., separation of whey, formation of gas, slow digestion, acid reaction.

Nitrates — strongly reduced to nitrites.

Indol — not formed.

Lead acetate — H_2S not formed.

Uschinsky's solution — no growth.

Cohn's solution — no growth.

Growth on raw potato. — Resembles heavy glistening drops. The medium becomes dark brown, soft, and there is a strong evolution of gas.

Acetylmethylcarbinol — produced.

Carbohydrates fermentation. Carbohydrates in a peptone-free medium were used (14). Glucose, lactose, sucrose, galactose, maltose, mannit, xylose, and glycerol were reduced to acid with a slight formation of gas. Mannose was also slightly reduced to acid with a slight formation of gas. However, in some repetitions glucose and

xylose were reduced to acid without formation of gas, but when chalk was added, evolution of gas always ensued.

A certain amount of acid is produced in dextrose yeast broth. Acetic, propionic, and very slight traces of butyric acid, are included in the volatile acids. No lactic acid was detected. Acetone was also produced in small quantities.

According to the above morphological and physiological study, the organism belongs to the family *Bacillaceae*, genus *Bacillus*, and is mesophilic. It appears to belong to the *Aerobacillus* Donker group, since it ferments carbohydrate with the production of both acid and gas. It has Clostridia like spores, and is very close to *Bacillus polymyxa* (3). These results were confirmed by Dr. W. J. DOWSON to whom a pure culture of the organism was sent, and who identified it as *Bacillus polymyxa* (Prazmowski) Migula (= *Aerobacillus polymyxa* Donker).

V. EXPERIMENTS

A. *Pathogenicity tests on Capsicum*

1. *Fruits.*

i. In order to ascertain whether the organism isolated from infected fruits brought from various parts of the country could be the cause of the above mentioned lesions, inoculations of the organism into healthy green sweet pepper fruits were carried out at room temperature which varied between 28°C—30°C, on the 5.9.1947, and 19.9.1947, respectively. 4 fruits were inoculated in each instance by the method described under (a) and 2 fruits were used as a control.

The same experiment was repeated on the 25.9.1947, by the method described under (b) in which special precautionary measures were taken to ascertain the purity of the cultures used for inoculation.

Positive results were obtained in all inoculated fruits. They showed symptoms similar to those described for the orginal specimens (plate VI, fig. 2). The places around the punctures in the inoculated fruits appeared as light brown, slightly sunken, soft spots on the 3rd day after inoculation, and attained a diameter of 6—10 mm on the 6th day. The epicarp as well as the endocarp of the fruits was affected.

The control fruits showed small white specks around the punctures, and remained thus throughout the experiment. No other change was observed. Free hand sections stained by Claudius' method revealed numerous bacteria in the epithelial and parenchyma cells of infected parts and very seldom in the vascular elements. Pure cultures were isolated from the lesions of inoculated fruits on potato dextrose agar at 30°C. Infection experiments were then carried out with the recovered organism on the 14.9.1947 as described above, and again positive results were obtained.

Infection experiments on green pepper fruits were also carried out by the method described under (c). No lesions were observed on the fruits; they remained healthy throughout the experiments.

Examination of the original organism isolated from samples brought from the South and centre part of the country with and without pasteurisation, and of the organisms recovered from inoculated fruits has proved that they were all identical.

ii. In order to examine the effect of temperature and humidity on the spread of the disease 4—6 detached pepper fruits in stoppered jars and 2 sweet pepper plants in pots were kept at constant temperatures of 30° and 37°C, and in the glasshouse (at a day temperature which varied from 30° to 37° and a night temperature of 18° to 20°) respectively. The fruits were inoculated on 14.6.48. At each temperature 2 fruits were used as a control and at least two detached and attached fruits of each plant were inoculated with a pasteurised and a non-pasteurised suspension of the organism as described under (d) and (h), respectively. The same experiment was repeated with other *Capsicum plants on* 23.6.48.

Positive results were obtained with all inoculated detached and attached fruits. However, infection was spreading more rapidly (a) at 37°C. that at 30°C., and (b) on the detached fruits in stoppered jars over water than on the attached specimens kept at the same temperature. The attached specimens at 30°C. showed symptoms similar to those described for the original and inoculated detached fruits kept in bell-jars. The places around the punctures in inoculated specimens appeared as light-brown, slightly sunken, soft spots on the 2nd and 3rd day after inoculation, and attained a diameter of 8—10 mm. on the 6th day after inoculation. Those at 37°C. showed similar spots which attained a diameter of 5—8 mm. already on the 2nd day after inoculation. The size of the lesions of the attached fruits kept in the glasshouse was larger than those kept at 30°, but slightly smaller than of those kept at 37°C. They appeared as slightly sunken spots with a very light brown centre and a darker band around it on the 2nd and 3rd day after inoculation (plate VI, fig. 3). Several days later the lesions became more homogeneous in colour, and appeared as slightly sunken brown spots.

The lesions on the detached specimens appeared as soft light brown spots which attained a diameter of 10—15 mm. on the second day after inoculation, at 37°C. The spots coalesced, and a soft rot of the entire fruits ensued 3 days later (plate VI, fig. 4) at 37°C., and about 8 days after inoculation at 30°C. The inoculated detached fruits at the glasshouse showed the same symptoms, but the progress of infection was slower than at 37°. However, there was no distinct difference between the progress of infection with the inoculated specimens kept in the glasshouse and those kept at 30°C. These results differed both from those obtained with the attached and detached fruits kept

in bell-jars, at 30°C. and 37C., where a complete soft rot of the fruits was never observed. We may, therefore, conclude that a saturated humid atmosphere is required for the organism to cause a complete rot of the fruits.

In all cases of infected fruits the epicarp as well as the endocarp of the fruit was affected. No distinct differences occurred between the results obtained by the inoculation of a pasteurized or a non-pasteurized culture.

The control fruits showed small, white specks around the punctures and remained thus throughout the experiment. No other change was observed. Free hand sections stained by Claudius' method revealed numerous bacteria in the epithelial and parenchyma cells of infected parts of inoculated fruits. Pure cultures from infected parts of inoculated fruits were isolated on potato dextrose agar. The organism recovered was identical with the original isolate.

2. *Leaves*

Sweet pepper leaves were inoculated on 31.12.47, as described under (f) and (g) and kept at 30° and 37°C. Two specimens in each case were used as a control. No apparent difference has been observed between the control and the inoculated leaves, either at 30° or at 37°C. The leaves showed slight brown spots on the scratched area. The sprayed leaves of both the control and the inoculated specimens did not show any change in appearance throughout the experiment.

B. *Pathogenicity tests on other hosts*

To test the pathogenicity of the organism on several other plants besides pepper fruits, infection experiments were carried out on samples of green tomato fruits, potato tubers, slices of potato, egg-plant, raddish, onion and carrot.

1. *Tomato fruits*

i. 4 green tomato fruits were inoculated on the 1.10.1947, by the methods described under (a), (b) and (c), respectively, at room temperature which varied between 28—30°C. 2 fruits were used as a control. Negative results were obtained with all inoculated specimens. The control fruits remained healthy throughout the experiment.

ii. In another series of infection experiments, 8 green tomato fruits were inoculated on the 15.12.47 by the method described under (*d*). 4 samples were kept at 30°C. and the other four — at 37°C. 2 fruits of each sample were used as a control.

Positive results were obtained with all the inoculated fruits. But the progress and extension of infection were both slower and smaller on inoculated samples kept at 30°C than on those kept at 37°C.

The inoculated tomato fruits have shown in most cases dry or soft — brown-grey spots around the punctures which attained an average diameter of 10 mm 5 days after inoculation at 30°C. Those at 37°C. attained an average diameter of 16 mm and appeared as soft wet brown-grey spots. The border between the healthy and infected

part was quite abrupt. In other cases, the skin was raised or shrivelled and separated from the flesh, and deep cracks developed on the infected parts of the fruits. The spots coalesced and a complete soft wet rot of the fruits with evolution of gas occurred about 8—10 days after inoculation.

iii. Inoculation of fruits attached to the plants was carried out as described under (h).

Two winter tomato plants and 2 summer tomato plants were kept at constant temperatures of 30 and 37°C., respectively and the fruits inoculated on the 19.3.1948 in the first case, and on the 14.6.48 in the second case. Two summer tomato plants were also kept in the glass-house at day temperatures of 30—38°C. and night temperatures of 18—20°C., and the fruits inoculated on the 14.6.48. On each plant one to two fruits were used as a control, and 2—3 were inoculated with a pasteurised and non-pasteurised suspension of the organism. To ensure the virulence of the culture and for comparison, two detached fruits of each plant were also inoculated and kept in stoppered jars with water at 30°, 37°C., and in the glass-house, respectively, and one additional fruit was used as a control.

Positive results were obtained with all inoculated detached and attached fruits. But there was a distinct difference a) between the infected specimens kept at 30°C. and those kept at 37°C., and b) between the infected attached and detached fruits at the same temperatures.

The infected detached fruits in stoppered jars have shown the same symptoms as those described under ii.

The inoculated attached fruits kept at 30°C. showed slight signs of infection and its progress and extension were both smaller than in those kept at 37°C. in the glass-house, and in the detached fruits kept at 30°C. They showed dry-grey white spots with a brown ring around them 3 days after inoculation. In some cases the spots became softer about 2 days later and obtained an average diameter of 5—6 mm. Those at 37°C. showed symptoms similar to the detached fruits kept in stoppered jars, but the progress of infections was slower. However, it progressed more rapidly than on the inoculated attached specimens kept in the glass-house. The lesions appeared first as soft brown-grey spots around the punctures (plate VI, fig. 5). They spread away from the paraffin covered punctures and obtained a diameter of 10—15 mm. 5 to 6 days after inoculation. The skin was shrivelling and separated from the flesh of the fruits (plate VI, fig. 6). In some inoculated fruits gas bubbled out from infected parts.

The lesions of attached fruits in the glass-house appeared as soft brown-grey spots around the punctures on the third day after inoculation. On the 6th and 7th day they showed the same picture of shrivelling and separation of the skin from the flesh, as described above.

There was no apparent difference between the results obtained

from the inoculation of a pasteurised culture and a non-pasteurised one.

The control fruits in all cases have shown white specks around the punctures, and they remained healthy throughout the experiment.

Pure cultures from the infected parts of the inoculated specimens were isolated on potato dextrose agar. The examination of the recovered organism has proved that it was identical with the original isolation. Histological sections showed numerous bacteria in the parenchyma cells of infected parts.

2. *Potato tubers*

8 young potato tubers in stoppered jars with water were inoculated on 15.12.47 by the method described under (d) and kept at constant temperatures, 4 at 30° and 4 at 37°C. Two fruits were used as a control at each temperature.

Positive results were obtained with all the inoculated tubers. But the extension of the lesion was greater at 37° than at 30°C. The tubers exhibited a soft brown rot around the punctures which 7 days after inoculation attained an average diameter of 15 mm. at 30°C. (plate VI, fig. 7), and extended to half the size of the tuber, with marked evolution of gas at 37°C. The control tubers remained healthy throughout the experiment. Free hand sections of infected parts stained by CLAUDIUS' method revealed numerous bacteria in the parenchyma cells. Pure cultures from infected parts of all inoculated specimens were isolated on potato dextrose agar. The examination of the recovered organism has proved that it was identical with the original isolation.

3. *Other vegetables*

Slices of potato, egg-plant fruit, radish, onion, and carrots were inoculated on the 15.12.1947, by the method described under (e), and kept at 30° and 37°C. 2 samples of each specimen were used as a control.

Positive results were obtained with all inoculated material in the presence of water. However, the degree of the extension of infection and its progress varied, according to the various specimens and depending of the temperature at which they were kept. The extension of infection was greater at 37°C than at 30°C with all inoculated specimens. A brown rot with strong production of gas was noticed in the inoculated potato slices, and was completed ten days after inoculation at 37°C. A soft rot was also produced on the radish as well as on the onion slices, but with slight production of gas, and was completed about the same time. The carrot specimens showed a brown soft rot with production of gas, and the egg-plant slices though showing signs of rotting were affected to a lesser degree.

No infection was observed on the inoculated material kept in Petri-dishes without water.

The control specimens remained healthy throughout the experiment.

VI. DISCUSSION

A. *Conditions of development of a phytopathogenic strain of Bs. polymyxa*

In this study, the first important point to determine was the cause of the fruits lesions, i. e. whether the disease was caused by a parasite. By the experimental work described above, sections, isolations, inoculations with controls, and re-isolations, it was clearly proved that the causal organism was a spore-bearing bacterium.

From the experiments carried out it appears (i) that the organism which is a wound parasite attacks the plant tissue at quite high temperatures: 30°—37°C., and requires a fairly humid atmosphere to invade the tissues (ii) that infection was both greater at 37°C. than at 30°C. and at a higher humidity that at a lower humidity, and (iii) that the pepper fruits were more readily attacked by the organism under conditions of lower humidity and lower temperature than the tomato fruits.

Whereas we failed to produce lesions on tomato fruits when kept in bell-jars at 28°—30°C. at a low relative humidity, and obtained only slight infection on the attached fruits at 30°C., we succeeded to obtain positive and better results with pepper fruits kept under the same conditions. These latter conditions appear to be similar to the natural field conditions. The average daily temperatures in July, August and September are approximately: minimum 20°C. and maximum 32°C. in the shadow, and the overhead irrigation system supplies quite sufficient humid atmosphere around the plant to enable the parasite to invade the tissue of the fruits. The inoculated leaves, however, did not show any distinct signs of infection. This last observation, as was stated before in a short report (18), is in agreement with that made by Dowson in Cambridge with another strain of *B. polymyxa*, used to inoculate stems of Iris and tomato plants which did not become infected, although kept under moist conditions and at a relatively high temperature. From the experiments carried out with tomato fruits attached to the plants it seems very likely that tomato fruits under natural field condiions, if wounded, are also liable to be infected by the organism, should favourable conditions of sufficient humidity and temperatures of 30—37°C prevail in the field. Such favourable conditions might present themselves occasionally at certain periods during the summer. It remains only to observe and prove this assumption in nature. Another interesting feature of this strain of *Bacillus polymyxa* is its ability to produce propionic acid in glucose fermentation.

B. *Spore-forming bacteria as plant pathogens*

The majority of bacterial diseases of plants which have been carefully studied so far, are caused by bacteria not forming spores. That some spore-forming bacteria of the *Bacillus subtilis* group can be pathogenic to plants has often been stated, but the evidence has

not been generally accepted by plant pathologists. Parasitism of spore-forming bacteria for potato tubers has been claimed by KRAMER (10) as early as 1891. He described a spore-bearing rod as the cause of a wet rot of tubers in Germany. In 1902, LEPOUTRE (11) mentioned *Bacillus mesentericus vulgatus* as one of the bacteria attacking potato tubers. About the same time VAN HALL (8) found Bacillus *subtilis* and *B. vulgatus* parasitic to potato tubers and to certain vegetables and nuts at high temperatures. There are, however, several accounts of experimental work which conform to the standards of rigid proof required in such work, and which leave no doubts as to the inclusion of spore-forming bacteria among the parasites of plants. BRIERLEY (4) isolated from a wound rot of potato tubers a spore-forming organism identified as *Bacillus mesentericus,* and showed quite definitely that pure cultures of this organism readily produced rot in healthy potatoes at 20°C and above. The pathogenicity of the cultures was retained after heating to 80°C for 15 minutes. It did not attack other plants or any parts of the potato but the tubers.

VERONA (17) in June 1934 isolated from the aerial parts of wilted asters (*Callistephus chinensis*) growing in a nursery at Leghorn a spore-forming organism identified as *Bacillus asteris.* He showed that pure cultures of this organism when inoculated on healthy asters produced a complete withering of the plants. The same organism was reisolated from the artificially infected plants. MADHOK and FAZAL-UD-DIN (12) in 1938 isolated a spore-forming bacterium from an underskin soft rot of tomato fruits in India, which belongs to the *Bacillus subtilis* group and for which the name *Bacillus fructodestruens* was proposed. They have shown quite definitely that the rot was caused by this organism. A bacterial rot of potato tubers has been investigated by DOWSON (5), in 1943—1944. He found a strain of *Bacillus polymyxa* to be responsible for this rot which transformed the interior of stored potato tubers into a gummy, transparent, mass, and induced complete decay when inoculated on fresh slices of potato, carrot, onion, cucumber and iris stems under laboratory conditions. ALLEN (1) has shown that certain strains of *Bacillus subtilis* secrete pectinases which rapidly disintegrate pieces of raw potato when immersed in their solutions, and which are concerned in the separation of flax fibres in retting. These last two investigations were summarized in "Nature" (6), 1944 as follows:— "From these investigations it would appear that some spore-formers of the *B. subtilis* group and *Bs. polymyxa* possess the necessary enzyme apparatus to attack and destroy the middle lamella of parenchymatous tissues under certain conditions, chief of which is the presence of water (not vapour), an adequate amount of which is necessary to start the enzyme system working". ASTHANA and MAHMUD (2) in 1945 showed that a spore-forming bacterial organism which they named provisionally *Bacillus betle* was the cause of leaf spots on the Bangla variety of *Piper betle* in India.

In 1946, A. W. JACKSON and A. W. HENRY (9) isolated *Bacillus polymyxa* from a variety of soils in Alberta, Canada. Twenty isolates were found to cause rotting of potato tubers and slices, when introduced through wounds, under conditions of abundant moisture and high temperature up to 45°C., but not below 30° for the tubers or 20° for the slices. However, despite its wide distribution the authors did not anticipate that it would be a serious cause of rotting in the field, since soil temperatures in Alberta are too low. But, according to them it may be of more importance under storage conditions, especially in conjunction with other organism. Although *Bacillus polymyxa* was isolated several times from rotted tubers, they have found that it was never the sole causal organism of the rotting. In the study carried out by us a strain of *Bacillus polymyxa* has been found for the first time to cause spots on green sweet pepper fruits, under natural field conditions, and to be pathogenic to a certain number of vegetables, including green tomato fruits, potato tubers, slices of carrots, raddish, egg-plant and onion under laboratory conditions at 30—37°C, and thus prove once more that certain spore-forming bacteria possess pathogenic power as regards plants.

VII. SUMMARY

A spot disease on green sweet pepper fruits, not hitherto described, was found in the south and centre of Palestine in August and September, 1947, and was caused by a spore-forming bacterium. The features of the lesions were: slightly sunken, light brown to grey, soft or dry spots, 8 to 12 mm in diameter, with quite definite a margin where the vessels appeared as distinct dark-brown threads crossing its length and breadth. The number of spots on each fruit varied from 1 or 2 to 5.

Histological examinations, pure culture isolations, inoculation experiments with controls and re-isolations showed definitely that the lesions were caused by this organism. The organism is easily isolated on potato dextrose agar, and forms circular colonies, glistening and jelly like, cream with a slight brownish tinge; it is a Gram positive rod which changes to Gram negative under certain conditions, is motile by means of numerous peritrichous flagella, capsulated, spores central, excentric, or sub-terminal, longer than wide, sporangia clostridia-like. Gelatine is liquified, milk coagulates, nitrates reduced to nitrites. Acid and gas are produced from glucose, lactose, sucrose, galactose, maltose, mannit, glycerol, xylose and mannose. Propionic acid is among the products of glucose fermentation. Optimum growth at 37°C., maximum temperature 50°C., minimum temperature 14—16°C. Spores do not germinate after being heated 10 to 20 minutes at 100°C. The organism was identified as *Bacillus polymyxa* (Prazmowski) Migula, a strain of which has been found to be pathogenic to stored potato tubers and a number of other vegetables under laboratory conditions.

The pathogenicity of the organism to sweet pepper leaves, to attached and detached tomato fruits and to a number of other vegetables under laboratory conditions has been tested. The inoculated pepper leaves failed to show signs of infection. The inoculated, attached and detached tomato fruits became infected, when kept in a sufficiently humid atmosphere and at a temperature of 30—37°C., and also in cases where the temperature varied from 18—20°C. during the night to 30—37°C. during the day. The spread of infection, however, was greater and more rapid at 37°C than at 30°C, and at a relatively higher humidity than at a lower humidity for both the inoculated detached and attached tomato fruits and the inoculated detached and attached Capsicum fruits. But the Capsicum fruits were more readily attacked by the organism under conditions of relatively lower humidity and lower temperature than the tomato fruits.

The presence of a saturated atmosphere and a temperature ranging between 30 to 37°C. was required to obtain positive results in the case of other vegetables. The spread of infection has been found to be greater and more rapid at 37°C. than at 30°C.

An account of plant diseases caused by spore-forming bacteria is also included.

Acknowledgment. The author wishes to express her thanks and gratitude to Dr. W. J. Dowson for his kind help and suggestions, and for reviewing this work.

REFERENCES

1. Allen, L. A., (1944). Spore-Forming Bacteria causing Soft Rot of Potato and Retting of Flax. *Natur* 153; 224.
2. Asthana, R. P., & Mahmud, K. A. (1945). A new bacterial leaf-spot on piper betle. *Curr. sci.* XIV, 3; 73, or *R. A. M.* vol:24; 289.
3. Bergey, D. H. Breed, R. S. Murray, E. D. G., & Parker-Hitchens, A. (1939). Bergey's manual of determinative bacteriology. A key for the identification of organisms of the class Schizomycetes. Williams and Wilkins, Co., Baltimore, U. S. A.
4. Brierley, P. (1928). Pathogenicity of Bs. mesentericus, B. aroide, B. cartovorus and B. phytophthorus to potato tubers. *Phytopathology* 18: 819—838.
5. Dowson, W. J. (1943). Spore-forming bacteria in potatoes. *Nature*, 152; 331.
6. Dowson, W. J. (1944). Spore-forming Bacteria Pathogenic to Plants. *Nature*, 154; 557.
7. Elsden, S. R. (1946). The applicaion of the Silica Gel Partition Chromatogram to the estimation of volatile fatty acids. *The Biochem. Journ.* 40(2): : 252—256.
8. Hall Van, C. J. J. (1902). Bacillus subtilis (Ehrenberg) Cohn und B. Vulgatus (Flügge). Mig. als Pflanzenparasiten. *Centralbl. Bakt Abt. II.* 9:642—652.

9. Jackson, A. W., Henry, A. W. (1946). Occurrence of Bacillus polymyxa (Praz.) Mig. in Alberta soils with special reference to its pathogenicity on potato tubers. *Canad. J. Res., Sect. c.*, 24 :39—46.
10. Kramer, E. (1891). Bakteriologische Untersuchungen ueber die Nassfäule der Kartoffelknollen. *Oesterr. landw. Centralbl.* 1 :11—26.
11. Lepoutre, L. (1902). Recherches sur la transformation experimentale de bacteries banales en races parasites des plantes. *Ann. Inst. Pasteur.* 16 :304—312.
12. Madhok, M. R., & Fazal-ud.din. (1943). Bacterial Rot of Tomatoes caused by a Spore-forming Organism. *Indian Journ. Agric. Sci. B.* 129—133.
13. Manual of Methods for Pure Culture Study of Bacteria. Society of American Bacteriologists, Leaflet IV, Staining, 8th edition, 1943.
14. Manual of Methods for Pure Culture Study of Bacteria. Society of American Bacteriologists, Leaflet II, Media, 9th edition, 1944.
15. Salle, A. Y. (1939). Fundamental principles of Bacteriology. p. 77. McGraw-Hill Book Co., Inc., New York and London, pp. 618.
16. Schneider, H. Z., & Zimmermann, A. (1922). Die botanische Mikrotechnik, p. 393—4. Gustav Fischer Verlag, Jena, pp. 458.
17. Verona, O. (1935). Di una batteriosi dell' Aster chinensis' L. Bac. asteris n. sp. *Riv. Pat. veg.* 25(1—2) : 15—24.
18. Volcani, Z., & Dowson, W. J. (1948). A Plant Disease caused by a spore-forming Bacterium under Natural Conditions, *Nature* 161 :980.

EXPLANATION OF PLATE VI

Fig. 1. — Green sweet pepper fruits bearing conspicuous light-brown to grey spots; original specimen.

Fig. 2. — Inoculated sweet pepper fruits showing an appearance of lesions around the punctures four days after inoculation.

Fig. 3. — Inoculated pepper fruits attached to the plant showing the appearance of lesions on the third day after inoculation in the glasshouse.

Fig. 4. — Inoculated detached pepper fruit in stoppered jar showing a complete rot of the fruit five days after inoculation at 37°C.; the control fruit (on the right) remained healthy.

Fig. 5. — Inoculated tomato fruits, attached to the plant, showing the appearance of lesions around the punctures at 37°C., two days after inoculation.

Fig. 6.— Another sample of inoculated tomato fruits attached to the plant, showing the appearance of infection six days after inoculation, at 37°C.

Fig. 7 — Inoculated potato tuber showing the appearance of infection at 37°C., seven days after inoculation.

METHODS OF ASSESSING THE INCIDENCE OF OLIVE LEAF SPOT*)

A contribution to the technique of plant disease estimation

By J. PALTI.
Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

INTRODUCTION

The necessity of evolving methods of accurately assessing the incidence of olive leaf spot (*Cycloconium oleaginum* Cast.) arose when phenological studies of this disease and fungicide trials for its control got under way at the Division of Plant Pathology in 1943. It was soon apparent that the task presented quite a number of problems not easily solved.

The purpose of this paper is to discuss these problems, to show how some of them were successfully tackled while others defied our efforts. In view of the dearth of literature on the technique of plant disease estimation, it is hoped that this contribution to an important aspect of phytopathological work may be of some value.

The terms used hereafter require brief definition: The first operation of recording the proportion of diseased tissue is termed a p p r a i s a l and this results in establishing the i n c i d e n c e of disease by grading the plant organs according to the relative area of diseased and healthy tissue. The second operation of attaching numerical values to each of the grades or categories of incidence is termed e v a l u a t i o n. The term e s t i m a t i o n is reserved to cover the two operations, so that the results of the estimation are considered to be those of appraisal duly evaluated.

APPRAISAL OF THE INCIDENCE OF OLIVE LEAF SPOT

Type of infection

Infection of the upper side of olive leaves by *C. oleaginum* may assume two types: (a) round spots of very variable sizes, usually from 3 up to 10 mm in diameter, which are often surrounded by a yellowish halo; (b) blackish irregular covering resembling sooty mould. Following Tehon and Stout's (6) terms for two types of apple scab, we might well term (a) the spot type and (b) the diffuse type of olive leaf spot.

It has never been established whether these two types of the disease are equivalent in their pathological significance. In fact, the impression was gained that this is not the case, as the spot type appeared to induce shedding of affected leaves rather more readily than the diffuse type. As one of the aims of the phenological studies

*) Received for publication in June 1946.

of the leaf spot was to determine the conditions conducive to the appearance of either type, it was obviously desirable to appraise the incidence of the two types separately.

Shedding of leaves

An important feature of olive leaf spot is the extensive shedding of infected leaves, and this cannot be disregarded in appraising the incidence of this disease. Now the symptoms of *C. oleaginum* on olive leaf blades are such that they are easily recognized for a long time after the leaf has shed. There is, of course, no way of proving that a leaf has actually shed because of the infection of its blade as on evergreen trees such as olives some of the leaves shed all the year round. It is, however, a reasonable assumption that on infected leaves the disease has been at least a contributing factor in causing the leaf to drop.

It is therefore possible to appraise the incidence of leaf spot on the leaves on the ground, subject only to one limitation: *C. oleaginum* sometimes attacks the leaf quite close to its petiole and then causes it to shed rapidly. This kind of infection is difficult to detect after the leaf has shed and cannot be satisfactorily accounted for.

Sampling

Leaves on the tree

On each tree 12 (sometimes 16) twigs were labelled so that 3 (or 4) each were situated on the N,E,S, and W side of the tree. Only twigs from which no leaves, or only very few basal leaves, had shed were selected and the label was affixed near the base of the lowest persisting leaf.

Leaves shed

Two or three frames, each delimitating an area of 0.75 sq.m., were placed below each tree after this area had been cleared of all leaves previously shed. At each appraisal 100 leaves in each frame were collected at random.

Units and categories of appraisal

Each leaf, whether of those on the tree or of those collected on the ground, was appraised separately, i.e. the unit of appraisal was a single leaf.

The categories of appraisal were as follows:

Category (*a*) — the leaf is free from disease = *healthy*

Category (*b*) — the leaf is affected with a single round lesion, covering considerably less than one quarter of the leaf surface = *very light infection*

Category (*c*) — up to one quarter of the leaf surface affected = *light infection*

Category (*d*) — up to one half of the leaf surface affected = *moderate infection*

Category (*e*) — up to three quarters of the leaf surface affected = *severe infection*

Category (*f*) — more than three quarters of the leaf surface affected = *very severe infection*

As stated above, the number of leaves in each category was recorded separately for either type of infection.

Procedure of Appraisal

The following procedure was adopted in appraising the incidence of olive leaf spot on each of the twigs previously labelled.

(1) Each of the leaves persisting on the twig was assigned to one of the categories of appraisal.

(2) The number of leaves shed from that twig was recorded.

(3) Each of the leaves making up the sample of shed leaves collected on the ground was assigned to one of the categories of infection. This last step was made only for purposes of phenological studies (cf. below).

EVALUATION OF DATA COLLECTED BY APPRAISAL

The method of evaluating data collected by appraisal must always be adapted to the specific purpose of the estimation and may differ widely for different purposes. The most important distinction is whether estimation aims at establishing only the extent of fungus development or whether the effect of the fungus on the host plant is also to be assessed. The former was the aim of our estimations for phenological studies of *C. oleaginum*, the latter in our fungicidal trials.

Evaluation to assess fungus development

In phenological studies of fungus diseases the aim is usually to define the extent to which the fungus has developed over a certain period and to bring such development into relation with seasonal or other factors. We are therefore concerned with estimating the growth of the fungus itself, as apparent by the external symptoms it produces, without regard to the effect on the host plant.

For this purpose the two above mentioned types of symptoms produced by olive leaf spot, the spot type and the diffuse type, can be appraised as well as evaluated by identical methods.

The central problem of evaluation, i.e. attaching numerical values (marks) to each of categories (a) — (f), is relatively simple in phenological studies. The number of marks can be roughly proportional to the leaf area covered by olive leaf spot. Thus, if a leaf affected up to one quarter of its surface (category c) is given 2 marks, a leaf affected up to three quarters of its surface (category e) should be given 6 marks. In fact, scales of marks of 0, 1, 2, 4, 6 and 8 have been used to denote categories (a), (b), (c), (d), (e) and (f), respectively.

Evaluation of data concerning the shedding of leaves presents a difficult problem in phenological studies. Whether or not an infected leaf sheds may certainly depend to a large extent on external factors, among which winds are the most obvious. But in a study of, for instance, the influence of seasonal factors on development of olive leaf spot it is impossible to distinguish to what extent increased shedding of infected leaves may be due to greater disease development or simply to the stronger winds prevailing at certain seasons. No satisfactory solution of this problem has been found, and in our evaluation of the data in question the play of external factors has been ignored. Thus the incidence of olive leaf spot on leaves that have shed has been defined by the use of the same scale of marks used for the leaves on the tree.

Thus evaluation of the incidence of olive leaf spot on each of the twigs proceeded by the following steps.

(1) Of the leaves persisting on the twig, the number determined to belong to each of the categories of appraisal was multiplied by the number of marks assigned to that category. The sum of the total of marks obtaining for all categories represents a value we refer to as "total marks for persisting leaves".

(2) Similarly, of the sample of leaves shed the number of leaves determined to belong to each of the categories of appraisal was multiplied by the number of marks assigned to that category. The sum of the total of marks obtaining for all categories was divided by the number of leaves in the sample to obtain the average infection mark of shed leaves.

(3) The average infection mark of shed leaves was multiplied by the number of leaves recorded to have shed from the twig. We thus obtain a value we refer to as "total marks for shed leaves".

(4) The total of marks for persisting and for shed leaves were added and the resultant figure was divided by the number of leaves originally recorded to be on the twig. This calculation yielded an overall disease rating for the twig for the purpose of phenological study.

Example: It was desired to evaluate for phenological study the data appraised on a twig on which 25 leaves had originally been recorded. At the time of appraisal 18 leaves persisted, 7 had shed.

(1) Of the persisting leaves

4	were in category	(a) (0 marks) =	0 marks
3	" " "	(b) (1 mark) =	3 marks
5	" " "	(c) (2 marks) =	10 marks
4	" " "	(d) (4 marks) =	16 marks
2	" " "	(e) (6 marks) =	12 marks
0	" " "	(f) (8 marks) =	0 marks
18	persisting leaves were thus assigned a total of		41 marks

(2) A sample of 200 shed leaves was collected in the frames. Of these

50	were in category	(a) (0 marks) =	0 marks
32	" " "	(b) (1 mark) =	32 marks
46	" " "	(c) (2 marks) =	92 marks
40	" " "	(d) (4 marks) =	160 marks
20	" " "	(e) (6 marks) =	120 marks
12	" " "	(f) (8 marks) =	96 marks
200	shed leaves were thus assigned a total of		500 marks, and the average infection mark for each shed leaf was 2.5.

(3) As 7 leaves had shed, the average mark of 2.5 was multiplied by 7, to yield a value of 17.5 for "total marks for shed leaves".

(4) Addition of the total marks for persisting leaves = 41
to the total marks for shed leaves = 17.5
yields a total of 58.5

Dividing this figure by the number of leaves originally recorded on the twig, we obtain 58.5 : 25 = 1.34 as the overall disease rating for the purpose of this estimation.

Evaluation of disease effect on the host

Evaluation of data of olive leaf spot appraisal in a manner that accounts for the effect of the disease on the host was found necessary in trials for the control of this disease. In determining the comparative efficacy of fungicidal treatments, the criterion by which results are to be assessed is evidently the measure of protection afforded to the crop, i.e. the extent to which the treatment has succeeded in preventing economic loss.

In general, the best way of accurately measuring such effects, is by yield measurements. Field estimations can never provide more than rough approximations and their important limitations are being discussed in detail in another paper (4). On the other hand in the case of fungicidal trials yield records alone are sometimes misleading, because of possible phytocidal effects of the treatments as pointed out by HORSFALL and HEUBERGER (1) and amply confirmed in our experience (5). Moreover, yield measurements are frequently out of the question, especially with tree crops where several years' records may be required to obtain reliable data. This is particularly true of the olive crop, as individual trees vary widely in their yields

and the level of yields fluctuates greatly from year to year. Under these circumstances field estimation of disease incidence is often called upon to fulfil a task it is not really suited for, and to try and assess the extent to which certain treatments have prevented losses.

In such cases it must be taken for granted that the incidence of the disease to be estimated is at least to some extent proportional to the yield of the crop. Thus phytocidal effects, if any, must be limited. If there are two types of infection which are known to differ in their effect on the host, the incidence of each type will have to be evaluated differently.

As regards olive leaf spot, although there are two types of infection and we suspected that one causes the shedding of leaves rather more readily than the other, this impression was still too vague to be taken into account in the evaluation of the data of field appraisals. Pending more accurate information on the subject, the two types of infection were therefore appraised and evaluated together without distinction.

On the assumption that the amount of economic loss caused by the disease is in some way proportional to the incidence of disease on the leaf, the relative proportion of affected leaf area was again taken as the basis of assigning marks to each category of infection, and the scale of marks used was the same as for phenological studies. This obviously ignores the possibility that, for example, infection in category (b) (less than 1/4 of the leaf surface = 1 mark) might have a negligible effect on the leaf, while infection in category (e) (up to three quarters of the leaf surface = 6 marks) might render the leaf useless to the tree and thus deserve much more than 6 times as many marks as category (b); or conversely, that even the slight infection of category (b) might suffice to interfere with the normal functioning of the leaf to such an extent (e.g. cause leaf drop) that all higher categories of infection should be given marks only slightly higher than those for category (b). These are points which, in our present state of knowledge, can only be settled arbitrarily.

The evaluation of data concerning the shedding of leaves requires a decision whether all the shed leaves found to be infected should be considered to have shed solely or primarily because of this infection. In the case of olive leaf spot we considered that this question could most probably be answered in the affirmative. Once this was decided, the evaluation of leaf shedding for the purpose of assessing the loss caused by disease on a given tree was simple: Every leaf shed is completely lost to the tree and should thus be given marks at least equal to that of the category defining very severe infection.

The effect of external factors, such as wind, on the extent of leaf drop is of minor importance where the losses caused by disease are to be compared in one season on trees growing in proximity, exposed to similar environmental conditions, and differing only in the treat-

ments they receive. However, where losses caused in one season are to be assessed in comparison with those of other seasons the play of external factors is as important as in the case of phenological studies, and equally difficult to determine.

Thus, where we desired to make the result express the measure of economic loss caused by the disease, the evaluation of the incidence of olive leaf spot on each of the labelled twigs followed the procedure detailed below:

(1) The "total marks for persisting leaves" were calculated as in phenological studies.

(2) In the sample of leaves shed the number of infected and sound leaves was determined without distinguishing the degree of infection.

The number of infected leaves in this sample was now multiplied by the number of marks applicable to the highest category of infection, and the result was divided by the total number of leaves in the sample. We thus obtained the average infection mark of shed leaves.

(3) and (4) Calculation of total marks for shed leaves and of the overall disease rating proceeded as for phenological studies.

Example: The twig described in the example on pp. 159—160, with 18 persisting leaves and 7 leaves that have shed, was to be evaluated in a fungicidal trial.

(1) Evaluation of the appraisal of leaves persisting on the tree remained unchanged and they were assigned a total of 41 marks.

(2) In the sample of 200 shed leaves, 150 were infected to some extent, while 50 were not affected. Each of the infected leaves was assigned 8 marks; the resultant total of $8 \times 150 = 1200$ marks was divided by the total number of leaves in the sample, to obtain the average infection mark of shed leaves of $1200 : 200 = 6$.

(3) As 7 leaves had shed, the average mark of 6 was multiplied by 7, to yield a value of 42 for "total marks for shed leaves".

(4) Addition of the total marks for persisting leaves $= 41$
to the total marks for shed leaves $= 42$
yielded a total of 83

Dividing this figure by the number of leaves originally recorded on the twig, we obtained $83 : 25 = 3.32$ as the overall disease rating for the purpose of this estimation, as compared with a rating of 1.34 when the appraised figures were evaluated for phenological studies.

Aggregate evaluation

So far we have evaluated only the incidence of disease on individual twigs. Further steps to obtain aggregate values expressing disease incidence on larger units again depend on the purpose of the estimation.

In phenological studies, where we may wish to study disease development on different sides of the tree, it may be convenient to calculate average estimates for all twigs (on one or more trees) with,

for example, a northern exposure as compared with those of southern exposure.

In general surveys and in fungicidal trials, on the other hand, it will be preferable to average results of all twigs labelled on a given tree to obtain an aggregate value expressing the incidence of disease on the tree as a whole.

DISCUSSION

While reserving a more comprehensive discussion of the problems of estimation to another paper (4), a comparison of our methods of olive leaf spot estimation with methods described abroad for comparable purposes may be of some interest. In particular the problems arising in the estimation of a disease causing tree defoliation appear worth discussing.

Of the principal diseases affecting fruit trees and causing defoliation, methods of estimation have been described for apple scab (*Venturia inaequalis*) by Moore (3) and by Tehon and Stout (6), for cherry leaf spot (*Coccomyces hiemalis*) by Keitt et al. (2), and for bacterial shot hole of peaches (*Pseudomonas pruni*) by Tehon and Stout (6). All these authors concentrate on accurate appraisal of the proportion of affected leaf area; the defoliating effect of the disease is either neglected entirely (3,6) or the percentage of defoliation is estimated separately and quoted apart from the data determined for the leaves persisting on the tree (2).

The estimation of olive leaf spot differs from the above cases in as much as olive trees normally shed part of their leaves all the year round, while with the deciduous fruit trees normal defoliation is limited to one season. Thus the olive leaves shed at any one season may comprise some shed naturally as well as others shed owing to disease attack; with deciduous fruit trees, on the other hand, leaf fall at any but the autumn season may often be held with reasonable certainty to be overwhelmingly due to the effect of disease.

It follows that with olives we cannot content ourselves with the determination of the total percentage of leaves shed, as practised by Keitt et al. (2) in estimating the incidence of *Coccomyces hiemalis* on cherries. In olive leaf spot estimations we have to determine the relative proportion of leaves shed owing to disease attack, by sampling and appraising the leaves shed. This further enables us to decide the degree of infection of leaves that have shed, a matter of obvious importance in phenological studies of defoliating diseases but practicable only where the disease produces symptoms clearly recognizable after leaf fall.

We note that none of the authors mentioned above has attempted to evaluate the significance of the leaves shed owing to disease attack, to obtain a single expression for the over-all incidence of disease. Tehon and Stout (6), dealing with apple scab, consider that defoliation of apples depends to so marked an extent on local conditions of soil and weather and on other factors affecting

the tree as a whole more pronouncedly than the disease, that leaf fall shoud be ignored in scab estimations and emphasis should be placed on the actual extent of leaf infection.

We agree that the variable influence of external factors may sometimes be marked enough to render estimation of defoliation of doubtful value where the aim is to compare the incidence of disease on trees growing under widely differing conditions or in consecutive years, such as was the purpose of Tehon and Stout's (6) surveys. But where olive leaf spot is concerned, we would nevertheless prefer to include defoliation data even in estimations for purposes of survey and phenological study, because we consider the inaccuracy certain to result from their neglection to outweigh the possible inaccuracies due to the play of external factors.

However, Tehon and Stout's (6) objection to defoliation data does not apply to estimations, on either deciduous trees or olives, where it is desired to establish the effect of fungicidal or other treatments on disease development. For such purposes use is usually made of trees growing under closely similar conditions and differing only in the treatment they receive. Here defoliation data are often strictly comparable and may add decisively to the accuracy of estimation results.

In olive leaf spot estimations, and probably in the case of other defoliating diseases, defoliation appraisals are particularly important (a) where strong winds prevail, and (b) where the incidence of disease on the leaves persisting on the tree is slight.

Strong winds, in addition to assisting the shedding of infected leaves, may greatly add to the number of sound leaves shed; it then becomes increasingly important to distinguish between the leaves shed naturally and those shed because of infection.

Slight incidence of leaf spot on the tree likewise provides ground for the assumption that among the leaves shed a high proportion may have done so for natural causes. At the same time, each leaf shed and found infected, which may receive relatively high marks in the evaluation process, may add substantially to the overall disease rating of an otherwise lightly infected twig. By contrast, where most leaves on the tree are severely affected, most of the leaves on the ground may be expected to be also infected; adding their marks to those of the leaves persisting on the tree will then affect the value of the overall disease rating to only a relatively slight extent.

Examples: Of 25 leaves on a twig to be estimated in a fungicide trial 18 have persisted.

(a) *Slight* infection — 11 leaves in category (a) = 0 marks
4 leaves in category (b) = 4 marks
3 leaves in category (c) = 6 marks

Average marks for 18 persisting leaves = 10 : 18 = 0.55

Of the leaves shed, 60% were infected, so that the average mark for each shed leaf was 0.6 x 8 = 4.8
For the 7 leaves shed we therefore add 7 x 4.8 = 33. 6
to the total of marks for persisting leaves 10

to obtain a total of 43.6
and an overall disease rating of 43.6 : 25 = 1.74

The overall disease rating is more than 300% as high as the value of 0.55, the disease rating obtained by estimating only the leaves on the tree.

(b) *Severe* infection — 2 leaves in category (c) = 4 marks
4 leaves in category (d) = 16 marks
6 leaves in category (e) = 36 marks
6 leaves in category (f) = 48 marks

Average marks for 18 persisting leaves = 104 : 18 = 5.78

Of the leaves shed 90% were infected, so that the average mark for each shed leaf was 0.9 × 8 = 7.2.

For the 7 leaves shed we therefore add 7 x 7.2 = 50.4
to the total of marks for persisting leaves 104

to obtain a total of 154.4
and an overall disease rating of 154.4 : 25 = 6.18

The overall disease rating in this case exceeds the rating obtained by merely estimating the leaves persisting on the tree by only 7%.

SUMMARY

Methods are described for appraising the incidence of olive leaf spot (*Cycloconium oleaginum*), taking into account the state of infection of leaves persisting on the tree as well as the defoliation caused by the disease.

The procedure to be adopted in the evaluation of data collected by appraisal differs with the purpose of the estimation, the principal difference lying in the evaluation of the leaves shed prematurely owing to disease attack. This is exemplified in detailed suggestions for the procedure to be followed in evaluation where the purpose is assessment of fungus development (phenological studies) and where it is desired to assess the effect of disease on the host (surveys, fungicide trials).

The merits of including defoliation data in disease estimations is discussed. In spite of the dependance of the amount of leaf fall on external conditions (winds), estimation of infection on the leaves shed is considered indispensable in olive leaf spot studies, especially where infection of the leaves persisting on the tree is slight and where strong winds prevail.

REFERENCES

(1) Horsfall, J. G., & Heuberger, J. W. (1942). Measuring magnitude of a defoliation disease of tomatoes. — *Phytopath.* 32(3) : 226—232.

(2) Keitt, G. W., Blodgett, E. C., Wilson, E. E. & Magie, R. O. (1937). The epidemiology and control of cherry leaf spot. — *Univ. Wisconsin Agr. Exp. Sta. Res. Bull.* 132, 117 pp.

(3) Moore, M. H. (1933). *Trans. Brit. Myc. Soc.* 18 :186.

(4) Palti, J., & Minz, G. Estimation of the incidence and destructiveness of plant diseases. (Ready for print).

(5) Reichert, I., Palti, J., & Minz, G. (1944). Field trials for the control of tomato leaf diseases. — *Palestine Journ. Bot., Rehovot Ser.*, 4(2) : 117—141.

(6) Tehon, L. R., & Stout, G. L. (1930). Epidemic diseases of fruit trees in Illinois 1922—1928. — *Bull. Illinois State Nat. Hist. Survey* 18 :415—502.

TRIALS FOR THE CONTROL OF OLIVE LEAF SPOT*)

By J. PALTI, S. MOELLER and I. REICHERT

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

INTRODUCTION

Olive leaf spot (*Cycloconium oleaginum* Cast.) has variously been reported from several Mediterranean countries (1, 2, 3, 4, 6) to be amenable to control by Bordeaux mixture spraying. The purpose of the trials to be described hereafter was to test the effect of both Bordeaux mixture and the cuprous oxide spray Perenox, and especially to determine the season at which spraying is best carried out in Palestine, and the number of annual applications required.

As the severity of olive leaf spot differs greatly with the variety and the locality, the trials comprised one variety, the Syrian, known to be highly susceptible as well as the Ascolano variety which is only moderately susceptible; two trials were carried out at Mikve Israel, near Tel Aviv, where the disease is often very severe, the third at G'vat, in the Western Valley of Esdralon, where disease development is more limited. The trials extended over three years, from 1943/44 to 1945/46.

METHODS

Sprays were applied with power sprayers working at 25—30 atmospheres' pressure.

A comprehensive discussion of the method used in assessing the incidence of olive leaf spot on sprayed and unsprayed trees has been presented elsewhere (5). Briefly, this method consisted in labelling 12—16 twigs on each tree and periodically estimating disease development on their leaves. Six categories of leaf infection were distinguished, the criterion being the area covered by lesions, and they were assigned 0, 1, 2, 4, 6, and 8 marks, respectively. The average of marks of the leaves persisting on the twigs was expressed as percentage of the highest possible mark, viz. 8, to obtain the "% disease rating of persisting leaves". The percentage of defoliation was then recorded. Samples were taken of the leaves shed from each tree and the incidence of disease on the leaves of these samples was estimated as above to obtain the "% disease rating of shed leaves". From these two ratings and the percentage of defoliation the overall disease rating was then calculated.

This method of estimation was gradually evolved as the work proceeded, and the first year's estimations still suffered from various shortcomings, e.g. neglect of the significance of the defoliating effect of the disease.

*) Received for publication in June 1946.

RESULTS

The effect of the spraying treatments on *Cycloconium* leaf spot is apparent from tables I—III and text-figs. 1 and 2. Both Bordeaux at 1% strength and Perenox (50% Cu in form of cuprous oxide) at ½% strength gave satisfactory control.

As regards the timing and frequency of spray applications we have to distinguish between conditions of severe infection, such as obtained in trial no. 1 with a susceptible variety in a locality favourable to the disease, and conditions of moderate or slight infection, such as experienced in trial no. 2 with a less susceptible variety in the same locality and in trial no. 3 with a susceptible variety in a locality less favourable to the disease.

Conditions of severe infection. In trial no. 1 on the Syrian variety at Mikve Israel, a single spray application made in November (1943/44) succeeded in greatly reducing disease development until February; but the disease subsequently progressed on the sprayed trees and in early April the effect of the spray could no longer be considered adequate. A second application made in March failed to affect disease development.

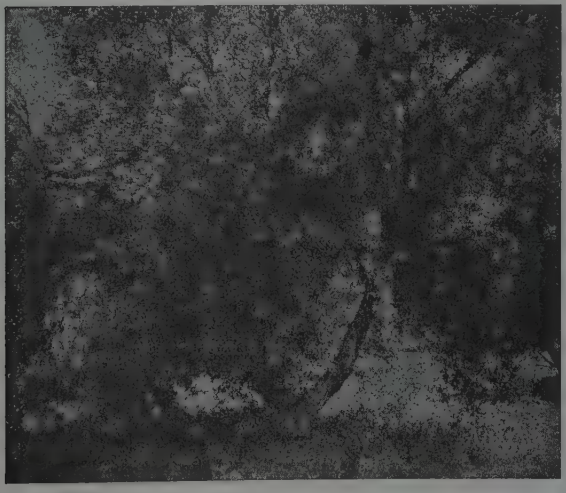
In 1944/45 two applications made in July and October kept the incidence of disease at a low level until January, and in April the effect of these sprayings was still seen to be satisfactory. Here again, an additional application made in February did not benefit the trees.

In 1945/46 the effects were compared of a single application made in August and of two applications, in August and November. In autumn the general disease development was still too weak to permit the effect of treatments to be assessed. But in April it was apparent that on the trees sprayed twice the level of disease incidence had been reduced almost to exactly the same extent as in the pre-year (overall rating 42%), while the trees sprayed only once had definitely higher disease ratings, especially on the leaves persisting on the trees.

These results permit the conclusion that under the conditions of severe infection obtaining in this trial a single application was inadequate, whether it was made in summer or autumn; a summer application followed by an autumn or early winter application gave satisfactory results; spring applications in addition to either summer or summer and autumn applications were ineffective.

Conditions of moderate infection. In trial no. 2 on the Ascolano variety at Mikve Israel results in 1943/44 showed a single application of spray in November to effect a definite reduction of disease; no advantage attached to a second application made in March. However, both in 1944/45 and 1945/46, though single applications in July-August were effective, second applications in October-November clearly had an additional effect and reduced the overall rating observed in April to very low levels.

Text-Fig. 1.
Trial No. 1, Mikve Israel. Unsprayed tree of the Syrian variety. Almost complete defoliation by olive leaf spot.



Text-Fig. 2.
Trial No. 1, Mikve Israel. Tree of the Syrian variety, sprayed twice.

TABLE I.

The effect of copper sprays on olive leaf spot.
Trial No. 1, Syrian variety, Mikve Israel.

	Control	*Sprayed once*	*Sprayed twice*	*Sprayed three times*
	No. of trees	*No. of trees*	*No. of trees*	*No. of trees*
1943/44. Bordeaux mixture 1% applied on 17.11.43 to trees sprayed once, on 17.11.43 and 23.3.44 to trees sprayed twice				
9.2.44	3	6		
% disease rating of persisting leaves	89.0	27.2		
17.4.44	3	2	4	
% disease rating of persisting leaves	99.7	67.8	78.0	
% total defoliation	25.6	34.5	42.4	
1944/45. Perenox ⅓% applied on 12.7. and 16.10.44 to trees sprayed twice, on 12.7 and 16.10.44 and 11.2.45 to trees sprayed three times				
% disease rating of persisting leaves	91		11	
10.1.45	3		8	
% total defoliation	61		13	
% disease rating of of shed leaves	95		84	
overall disease rating	**94**		**19**	
29.4.45	3		4	4
% disease rating of persisting leaves	—		25	16
% total defoliation	100		36	41
% disease rating of shed leaves	92		77	75
overall disease rating	**92**		**43**	**41**
1945/46. Perenox ⅓% applied on 7.8.45 to trees sprayed once, on 7.8. and 8.11.45 to trees sprayed twice				
12.10.45	3	10		
% disease rating of persisting leaves	7.8	3.1		
% total defoliation	22.8	22.9		
7.4.46	3	4	6	
% disease rating of persisting leaves	53.9	40.0	18.6	
% total defoliation	54.5	40.4	36.0	
% disease rating of shed leaves	97.4	92.8	84.4	
overall disease rating	**76.1**	**61.1**	**42.2**	

TABLE II.

The effect of copper sprays on olive leaf spot.
Trial No. 2, Ascolano variety, Mikve Israel.

	Control		*Sprayed once*		*Sprayed twice*	
	No. of trees		*No. of trees*		*No. of trees*	
1943/44. Bordeaux mixture 1% applied on 17.11.43 to trees sprayed once, on 17.11.43 and 23.3.44 to trees sprayed twice						
9.2.44	3		8			
% disease rating of persisting leaves		16.3		3.4		
4.4.44	3		2		6	
% disease rating of persisting leaves		22.3		7.7		5.1
% total defoliation		25.6		8.8		10.9
1944/45. Perenox ⅓% applied on 12.7.44 to trees sprayed once, on 12.7. and 16.10.44 to trees sprayed twice						
10.1.45	3		3		3	
% disease rating of persisting leaves		23		13.6		0.3
% total defoliation		36		8		0
% disease rating of shed leaves		69		57		0
overall disease rating		**40**		**18**		**0.3**
29.4.45	3		3		3	
% disease rating of persisting leaves		12		15		2
% total defoliation		86		59		1.3
% disease rating of shed leaves		45		21		19
overall disease rating		**41**		**17**		**1.8**
1945/46. Perenox ⅓% applied on 7.8.45 to trees sprayed once, on 7.8. and 8.11.45 to trees sprayed twice						
12.10.45	3		3		6	
% disease rating of persisting leaves		0.7		0.4		0.6
% total defoliation		11.1		16.9		20.3
7.4.46	3		3		6	
% disease rating of persisting leaves		20.6		8.1		1.0
% total defoliation		43.8		29.7		25.7
% disease rating of shed leaves		80.1		58.5		39.0
overall disease rating		**46.6**		**23.0**		**10.8**

TABLE III.

The effect of copper sprays on olive leaf spot. Trial No. 3, Syrian variety, G'vat.

	Control	*Sprayed once*	*Sprayed twice*
	No. of trees	*No. of trees*	*No. of trees*
1945/45. Bordeaux mixture 1% applied on 27.7.44 to trees sprayed once, on 27.7.44 and 18.10.44 to trees sprayed twice			
30.1.45	4	3	7
% disease rating of persisting leaves	33	0.2	0
% total defoliation	10	2	1
% disease rating of shed leaves	48	2	2
overall disease rating	**36**	**0.28**	**0.02**
24.4.45	4	3	7
% disease rating of persisting leaves	27	4	0.3
% total defoliation	83	4	5
% disease rating of shed leaves	51	12	13
overall disease rating	**44**	**5**	**1**

In trial no. 3 on the Syrian variety at G'vat the incidence of disease in 1943/44 was too low to permit observation of results. In 1944/45 a single application made in July proved so very effective in suppressing olive leaf spot that a second application in October could do little to improve the position.

We conclude that under conditions of moderate infection a single summer application will go far to reduce the incidence of olive leaf spot. A second application in autumn may often suppress the disease almost entirely, but it appears doubtful whether this warrants the additional expense incurred.

DISCUSSION

The control of *Cycloconium oleaginum* by spraying with Bordeaux mixture, usually at 1% strength, has been recommended in Spain (1), France (2), Italy (3, 6), and Cyprus (4). We can confirm the efficacy of this treatment and add that the cuprous oxide spray Perenox, at a concentration corresponding to $^1/_6$% metallic Cu, has also given entirely satisfactory results.

Decisive for the success of spraying against olive leaf spot is the correct timing of the operation. In France (2) and Italy (3) growers have been advised to spray in spring and summer. In Spain (1) applications were recommended for spring and autumn. Similarly, in Cyprus (4) spraying was advised before flowering and after the fruit has been picked.

Our results have shown that in Palestine spring application of sprays are of little value, whereas good results have been obtained under conditions of severe infection by summer and autumn applications, and under conditions of moderate infection even by a single summer application. These results appear logical when viewed in relation to the seasonal growth of olives in Palestine. Here the young growth begins to show in late March and continues to develop through the summer. As the infection appears to take place in most of the months of the year, the best time to apply sprays would be when most of the young growth has already been made but before there has been time for extensive infection, i.e. in summer or, where conditions favour extensive disease development, in summer and autumn.

Acknowledgement. The authors are indebted for co-operation in these spraying trials to Messrs. Nehemia Vovolsky and Yitshak Lerner, Mikve Israel, Mr. Israél Perlov, G'vat, Messrs. F. Genazzani and Z. Avner, Tel Aviv, and Dr. Z. Avizohar-Hershenson, Rehovot.

SUMMARY

Olive leaf spot (*Cycloconium oleaginum*) was satisfactorily controlled in 3 trials extending over three years by Bordeaux mixture at 1% (0.25% Cu) and by the cuprous oxide spray Perenox at ⅓% strength (0.17% Cu).

Under conditions of severe infection a single application was inadequate. Two applications, in summer and autumn, gave good results. Spring applications in addition to either summer or summer and autumn applications were without effect.

Under conditions of moderate infection a single application of sprays in summer largely controlled the disease.

REFERENCES

1. Benlloch, M. (1928). Sobre el tratamiento de "repilo" o caida de las hojas de los olivos. — *Bol. Pat. Veg. y Ent. Agr.* 3 :1—8.
2. Bernes, J. (1923). Les parasites de l'olivier au Congrès oléicole de Nice. *Prog. Agric. et Vitic.* 53 (47) :518—524.
3. Giulivo, G. (1927). Il vaiolo dell'olivo. — *L'Istria Agric.* 7 :229230.
4. Nattrass, R. M. (1935). Diseases of the olive. — *Cyprus Agric. Journ.* 30(2) :55—57.
5. Palti, J. (1949). Methods of assessing the incidence of olive leaf spot. — *Pal. Journ. Bot., Reh. Ser.,* 7 :156—166.
6. Paoletti, V. (1933). Osservazioni ed esperimenti orientativi di lota contra la rogna dell'olivio. — *Riv. Pat. Veg.* 23 :47—50.

MASS SPORE PRODUCTION OF DIPLODIA NATALENSIS AND SOME OTHER FUNGI PATHOGENIC TO CITRUS FRUITS

By F. LITTAUER and J. GUTTER
Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

Large quantities of spores from the same source and viable for long periods are frequently needed in studies of the biology and pathogenicity of a fungus. The natural source of such quantities of *Diplodia natalensis* P. E. are blighted citrus twigs, but the spores are frequently contaminated with other microorganisms. In ordinary cultures on 2% potato-dextrose agar, as well as on other media, the production of pycnidia and of viable spores is sometimes sparse and inconsistent. When cultured on sterilized citrus twigs *D. natalensis* fructificates abundantly, but the spores are easily discharged.

Brooks (1) obtained good spore production on wheat seeds. The spores were, however, mostly hyaline, single-celled and failed to germinate when kept at 80°F (27°C) for more than 5 weeks. The darker two-celled spores germinated in water very poorly. In prune juice, however, both spore forms germinated well. Since Kent (2) obtained good spore production on a thin layer of oatmeal-extract agar, various seeds, other than wheat, were tested as a suitable substrate for a mass production of Diplodia spores of long viability.

METHODS

Seeds of sweetcorn (*Zea Mays saccharata*), dentcorn (*Zea Mays indentata*), oat (var. Mulga and another unstated variety), barley (var. B.M.C.) and wheat (var. C.C.C.) were soaked for 20—24 hours in distilled water and then sterilized in test tubes or Erlenmeyer flasks, after the excess water was drained off. The seeds were inoculated with a watery spore suspension of *D. natalensis* and kept either in the laboratory under normal conditions of light and temperature (17—28°C) or in complete darkness at 25°C.

SPORE PRODUCTION OF *DIPLODIA NATALENSIS*

Formation of pycnidia and spores. — Good formation of pycnidia was observed on oat seeds 4 days after inoculation and on the other seeds 1—2 days later. The pycnidia on all seeds were small, naked and scattered. After 4 weeks the spores were discharged easily, their majority being brown and two-celled, the remainder hyaline and one-celled. Both types of spores germinated freely; only the hyaline spores from wheat seeds germinated poorly and this is in agreement with the findings of Brooks (1). Especially abundant hyaline formation of pycnidia and spores, along with sparse development of mycelium was observed on the oat seeds.

Viability. — The viability of spores was determined throughout two years by percentage germination counts and was once tested by seeding one year old spores on 2% potato-dextrose agar in Petri dishes.

The percentage germination of spores at various time intervals after inoculation on seeds is set out in table I.

TABLE I.

Percentage germination of spores of Diplodia natalensis on various cereal seeds, 1—23 months after inoculation

	weeks				months				
	4	6	8	10	3	4	6	12	23
Oat	100	100	>80	100	100	100	100	100	<15
dent corn	100	100	100	100	100	100	100	50	0
barley	100	100	70—80	50—70	25—30	10	0	0	f
wheat	90—100	10	f	0	0—20	10	0	0	0
sweet corn	70—80	<20	f	10—20	f	0	0	0	0

f = only a few spores germinated

These figures show that the viability of *Diplodia* spores from all substrates was high after 4 weeks; only the viability of spores from wheat and sweetcorn deteriorated greatly after 6 weeks. The next to deteriorate progressively after 8 and 10 weeks were the spores from barley. Those from oat and dentcorn retained their viability over a much more extended period.

The seeding test yielded abundant pycnidia and spore formation from spores grown on oat seeds; one positive case only was obtained with spores grown on dentcorn, and negative results with spores from the remaining substrates.

Virulence. The virulence to Shamouti oranges of one year old spores was tested by inoculating them into the stylar-end of ripe fruits. The inoculations were successful with spores from oat and dentcorn seeds only.

The influence of light has been observed and it was found that keeping inoculated seeds in complete darkness delayed the formation of pycnidia by 3—4 days. The fungus grown in darkness produced more hyphae and a larger percentage of hyaline spores than that grown in diurnal light.

SPORE PRODUCTION OF FUNGI OTHER THAN *DIPLODIA*

The suitability of oat seeds as a substrate for mass spore production was tested with a further 12 fungi pathogenic to citrus fruits. The following fungi were included in the experiment:

Sphaeropsis sp.	*Fusarium sp.*
Phomopsis citri	*Penicillium italicum*
Alternaria citri	*Penicillium digitatum*
Colletotrichum gloeosporioides	*Phytophthora citrophthora*
Trichoderma sp.	*Phytophthora parasitica*
Oospora Citri Aurantii	and *Sclerotinia sclerotiorum.*

Good results — abundant formation of pycnidia and spores — were obtained only with *Sphacropsis* and *Phomopsis*, fungi which belong with *Diplodia natalensis* to the *Sphaerioïdaceae.*

SUMMARY

Of 5 types of cereal seeds tested for their suitability as substrates for mass spore production of *Diplodia natalensis* P. E. sterilized oat seeds were found to be best, yielding abundant spores viable and virulent for at least 12 months. Darkness delayed the formation of pycnidia of *D. natalensis* on these seeds. 12 other fungi pathogenic to citrus were tested on oat seeds, but good growth and pycnidia formation were obtained with *Sphaeropsis* and *Phomopsis* only.

REFERENCES

1. Brooks, Ch. (1944). — Stem-end rot of oranges and factors affecting its control. — *Jour. Agr. Res.* 68(10) :363—381.

2. Kent, G. C. (1946). — Some factors in the production and germination of spores of Diplodia zeae in culture. — *Iowa State College Journal of Science,* 20(2) :259—263.

NOTES

THE WATER TURN-OVER OF THE VALONEA OAK

By H. R. OPPENHEIMER

Division of Citriculture and Agricultural Botany, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

In the course of his studies on the water balance of Mediterranean trees and shrubs, the author investigated in 1946 the transpiration of various species in the Carmel region. Among these Valonea Oak, *Quercus ithaburensis*, showed surprisingly high figures of water expense, which warrant a short note.

On June, 28th, leaves were plucked from the sunny side of a low-headed tree growing in southern exposure on the Harbushiyé hill near Bat-Shlomo, where only a shallow soil layer covers the white and soft calcareous rock. Weighing a leaf immediately after plucking, on HUBER's transpiration balance, we found at 15.27 p.m. — with an air temperature of 30.9°C and a humidity of 55%, — a loss of no less than 925 mg. per gram fresh weight per hour. Injection tests showed that the stomata were very widely open. Subsequent weighings continued to yield very high figures; these conform closely to those established earlier (Ber. D. Bot. Ges. 50a; 1932) for the almond, the root system of which can be considered as a powerful suction pump delivering plentiful water from apparently dry soil . The highest figure of 1095 mg./g h was attained at 16.35 p.m.. Later on, figures dropped . But shortly before sunset, when light intensity on a horizontal surface in the open had declined to 5,800 metre candles, the loss was still 490 mg/g h.

The next morning we investigated an isolated large oak tree of the same species at the foot of the hill, on which the colony of Bat-Shlomo is situated. This tree has a height of about seven and a spread of about nine metres. The trunk, breast-high, is about 45 cms. thick. Temperature and humidity were typical for a normal, somewhat cloudy summer day, the former rising from 26.4° at 08.00 a.m. to 28.6° at 10.47 a.m., the latter falling correspondingly from 73 to 62%.

Again very high figures of water expense were found, ranging, in leaves from the sunny side of the tree, between 800 and 1000 mg/g h, when the leaves were struck by the sun being kept at their natural place of insertion between the first and the second weighing. If the sun was covered by clouds, the losses of these leaves ranged from 500 to 700 mg/g h. In the shade, figures were still lower (at 10.30 a.m.) : 556 mg in one case, 258 in another.

As would be expected so high a transpiration intensity does not persist for long after the leaf has been plucked. In a leaf losing weight during the second to third minute after isolation at a rate of 842.5 mg/g h, the loss in the next two minutes fell to 599, in the following two minutes to 330,, and ten minutes after the first weighing to only 152. This series of weighings shows that quick work and very short weighing periods are necessary with such species, if it is desired to obtain figures reflecting natural conditions. The decline of transpiration intensity is probably a consequence of stomatal regulation. But this could not be established since the structure of the leaves of this tree is unfavourable for the use of MOLISCH's injection method. In fact, we obtained on that day clearly perceptible spots only with the softer leaves on the Harbushiyé hill. The spots could be observed, if at all, only on the *upper* side of the leaf, since the lower side is covered with tomentous hairs. Yet by this method, infiltration of a mixture of turpentine and castor oil and even of paraffin oil had been observed the day before.

There are good indications that the tree balances its water budget till the end of the dry season. Investigating transpiration of the same trees once more on September 21st, 1946, a very hot and dry day, we found again surprisingly high water losses and wide open stomata. At 08.30, losses at Bat-Shlomo were higher than 1000 mg/g h, falling at 11.00 to about 500. In the afternoon figures on the Harbushiyé hill averaged about 650 mg/g h. It would seem, therefore, that the tree is not compelled to restrict transpiration to any decisive degree even on hamseen days after as much as five months of complete drought.

The same conclusion can be drawn from a determination of the osmotic value of the leaf sap at this season. Taking a sample from an old specimen at Zikhron Yaaqov on October 8th, 1946, we were able to squeeze out an ample amount of sap which had a freezing point depression of —1.69°, corresponding to 20,32 atmospheres; this figure does not appear unduly high for a tree of this kind. No signs of water shortage or premature shedding were found on close observation of the top. It would seem, therefore, that the tree finds sufficient moisture in the rock during the whole summer, at least if it is adequately spaced.

But the availability of water in the root zone would probably not permit the tree its "careless" water economy, if its wood were not built for the passage of relatively large water streams. The wood anatomy of the Palestinian oaks has been investigated by Dr. I. GINDEL, and he informed the author that *Quercus ithaburensis* has very wide vessels, several times wider than those of the evergreen *Quercus calliprinos*. This agrees with our own, unpublished results showing that the transpiration of the latter species fluctuates in summer about 200 mg/g h only.

It seems probable that the high water requirement of the Valonea oak provides a clue to the understanding of its wide spacing in its natural habitats. Indeed, it forms only park-like woods, instead of closed forests. The individual tree evidently needs a free stand, otherwise its development would be restricted by lack of water. Foresters should pay attention to this specific requirement, especially if mixed forests are sown or pines are planted between old oaks. It might happen that the water reserves of the soil prove in the long run insufficient for such interplanting, as is observed in olive groves, where interplanted vines often hamper the development of the olives planted as permanent crop, and both produce unsatisfactory yields.

Our observations on the Valonea oak provide another example of a deciduous tree with high transpiration intensity, comparable to the almond, fig and plum investigated in earlier studies. Indeed, the figures of water loss are of the same order as those of well irrigated citrus trees.

THE EFFECT OF SODIUM ISOPROPYL XANTHOGENATE ON SHAMOUTI ORANGES

By J. PALTI and Z. AWNER, Tel Aviv.

Weed control by chemicals is receiving much attention in Palestine in recent seasons. Among the materials suggested for this purpose, sodium isopropyl xanthogenate (n.i.x.) gave promising indications of action on several widespread weeds in preliminary tests. Before proceeding with larger experiments in citrus groves, it was deemed advisable to determine the effect of n.i.x. on citrus. A series of experiments was accordingly laid down under conditions likely to bring out to the full any injurious effect the material might have on the citrus species most widely grown in Palestine, the Shamouti orange. The experiments were thus carried out in summer on unirrigated trees.

Thanks are due to Dr. L. Haskelberg, Daniel Sieff Research Institute, Rehovot, who prepared considerable quantities of sodium isopropyl xanthogenate for these experiments.

EXPERIMENTAL RESULTS

Concentrations and rates of application.

The experiments comprised tests of various concentrations of spray as well as various rates of spraying. Spreading materials were always added to the spray.

First observations were made on trees sprayed with n.i.x. at 2.75% at the extremely heavy rate of 700 litres per dunum (=1000 sq. metres), amounting to an application of almost 20 kg. to that area. The effect on the orange trees was rapid. 60 hours after the applica-

tion about 80% of the leaves had shed, and fruits were shedding fast. After 7 days 90% of the leaves and all of the fruits had shed. After 11 days many twigs of last year's growth began to dry up.

In the following tests n.i.x. was tested at a similar concentration (3%), but the rate of application was drastically reduced to 5.5 kg. per dunum. For comparison, a 1.5% spray applied at 3.5 kg. per dunum was also included. Treatment effects were slower to appear than in the first test, and there was little difference between the trees sprayed with 3% or 1.5%. After four days, up to 50% of the leaves had shed; most of the fruits were scorched, and some were shedding. After 11 days defoliation had not progressed much, but every single fruit had shed on all trees; the twigs were not killed. Observations after 3 months showed that up to 70% of the foliage had gradually shed.

Description of effects.

Characteristic of the effect of n.i.x. spray on Shamouti oranges is its strict localization: only leaves or fruits actually covered by the spray are affected in any way. When only the lower branches of trees were sprayed, as might occur in the process of weed control, only leaves and fruits on these branches were scorched and shed, while the upper part of the tree remained entirely normal.

The leaves of branches sprayed with n.i.x. first pale slightly; subsequently, while still greenish, they abscind at their base, with the leaf stalk persisting on the tree. No symptoms of leaf scorching were observed at the concentration tested.

The fruits, on the other hand, at the walnut-size stage they had reached when these tests were carried out, immediately show dark brown scorching marks. The fruits, like the leaves, abscind with the stalk persisting on the tree.

CONCLUSIONS

In a recent paper on the use of n.i.x. as a herbicide, Baumgartner and Wolf (cf. Supplement to the Proceedings of the Northeastern Weed Control Conference, January 1949, p. 30—39) have pointed out that the efficacy of the material is reduced by heavy rainfall and heightened by high temperatures. Nevertheless, good control of most annual weeds was obtained by these authors even under unfavourable conditions by applications of 30 lbs. n.i.x. per acre (3.5 kg. per dunum).

In Palestine the weed control season in orange groves is winter and spring, and in these seasons the effect of n.i.x. on the oranges may be expected to be less pronounced than under the summer conditions of our experiments. In view of the strictly localized action of n.i.x. sprayed there would appear to be very little danger of injury to the trees if reasonable precautions are taken, though occasional leaves may be hit by the spray. At any rate, dosages such as those found effective for herbicidal purposes in the United States are very unlikely to be injurious if properly applied.

The specific abscission effect of n.i.x. on the leaves, and particularly on the fruits, of Shamouti oranges merits further study.

CONTROL OF BROWN ROT IN CITRUS FRUITS WITH NITROGEN TRICHLORIDE

By
F. LITTAUER and MINA NADEL-SCHIFFMANN
Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

Nitrogen trichloride (NCl_3), applied at the rate of 1 mg. per cb. ft. air for 6 hours, was found to kill spores and mycelium of *Phytophthora*, the cause of brown rot in citrus fruits*). However, a considerable amount of brown rot was often observed after storage of naturally infected fruit treated with NCl_3.

To elucidate this phenomenon, experiments with NCl_3 treatment were carried out in 1948/49 with artificially infected fruit and with fruit naturally infected in the grove.

(a) *Artificially infected fruit*

There was reason to assume that the success of the NCl_3 treatment in controlling brown rot of oranges depends upon the time elapsing from infection to treatment. An experiment was therefore carried out to test the effectiveness of NCl_3 on fruit treated 16, 24, and 48 hours, respectively, after artificial infection with the fungus *Phytophthora citrophthora* Sm. and Sm.

Shamouti oranges were inoculated with *P. citrophthora* the day after picking by dipping them into a watery suspension of the culture. To render infection possible the fruit was kept under moist conditions from inoculation to wrapping and subsequent treatment. Each item comprised 100 fruits, while 100 infected but untreated, wrapped fruits served for comparison. After treatment, the fruit was kept in a store room, at 8—12°C, and was examined 16 days after inoculation.

Results. The infected fruit kept under moist conditions for 16 hours from inoculation to treatment, yielded 1 percent brown rot, while in the untreated fruit 13 percent brown rot was found. After 24 hours, the percentage of brown rot in treated fruit was nil, and in untreated fruit 30 percent. After 48 hours the percentage of rot was 33 and 38 percent in treated and untreated fruit, respectively.

These results show that NCl_3 is effective in controlling brown rot only if applied to the fruit shortly, not later than about 24 hours, after inoculation.

(b) *Naturally infected fruit*

To test the effectiveness of NCl_3 in controlling brown rot occuring on naturally infected fruits, Shamouti oranges and Marsh grape-

*) Klotz, L. J. (1936). Nitrogen Trichloride and other gases as fungicides. — *Hilgardia*, 10(2):27—52.

Littauer, F. (1947). Control of Diplodia stem-end rot and moulds in Shamouti oranges with Nitrogen Trichloride (Decco Process). — *Palestine Journal of Botany Rehovot Series, Vol.* 6:206—218.

fruit were selected from a grove known to be infected with brown rot, at Mikveh Israel, on heavy soil. Fruit was picked on 12th March 1949 from the lower part of the tree (up to 1 m.) 5 to 6 days after the last preceding rain, wrapped and packed the day after picking and treated with NCl_3 on the following day (2 days after picking). The fruit was stored in the same store as the artificially inoculated fruit.

Results. Almost no difference was found in the percentage of brown rot in treated and untreated fruit. Rotting in untreated Shamouti oranges amounted to 7 percent, and in treated fruit to 6.7 percent. In untreated grapefruit, the amount of rotting was 16.5 percent, and in those treated 15 percent. These negative results to control brown rot with NCl_3 confirmed previous observations on stored fruit.

The experiments with artificially infected fruit showed that the success of NCl_3 treatment in controlling brown rot of citrus fruit depends upon the time elapsing from infection to the application of NCl_3. When applied after a short incubation period the treatment was successful, but after 48 hours' incubation it failed to control rotting. It may be presumed that by this time infection of the fruit by *P. citrophthora* is too advanced to be inhibited by the gas.

These results explain the failure of NCl_3 to control brown rot in commercial practice, with naturally infected fruit, where the treatment is generally applied at least 48 hours after picking to fruits on which infection is already well established.

SCLEROTIUM BATATICOLA AS A POTENTIAL PATHOGEN OF VARIOUS CITRUS FRUITS

By G. MINZ AND J. GUTTER

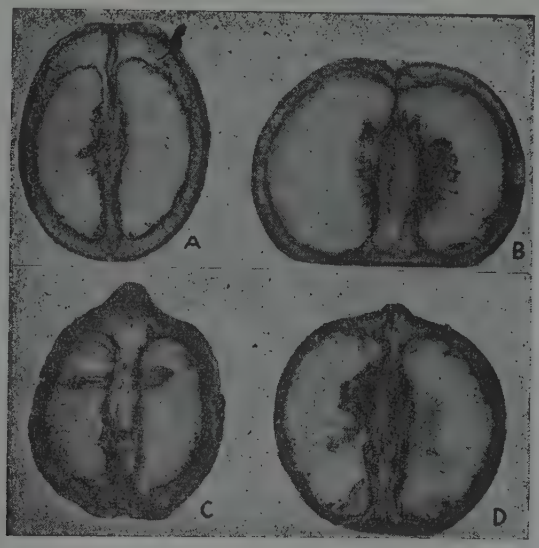
Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

Littauer and Gutter *) found *Sclerotium bataticola* Taub. on Shamouti orange fruit, and proved its pathogenicity, when isolated from this and various other hosts, to Shamouti orange fruits. The present authors isolated *S. bataticola* from grapefruit fruit found in a grove near Rehovot. The rot was of the pliable type of stem-end rot, light brown in colour, and resembled that caused by *Diplodia natalensis* P. E. commonly found in this country on citrus fruits.

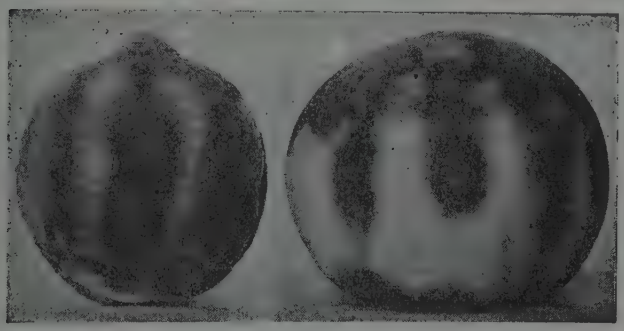
The sclerotia from culture measured 50—150μ in diameter, with an average of 90μ.

*) Littauer, F. & Gutter, J. (1946). *Sclerotium bataticola* Taubenhaus as causal agent of rot of Shamouti oranges. — *Pal. J. Bot., Reh. Ser.*, 5:261—262.

Inoculations were made on Marsh grapefruit, Shamouti and Valencia oranges, Eureka lemon, and sweet lime. Sclerotia from the above mentioned culture isolated from grapefruit served as inoculum. The earlier isolate from Shamouti orange was also included in the tests.



Text — fig. 1. The results apparent 4 weeks after inoculation of various citrus fruits with *S. bataticola* from grapefruit. Shamouti orange (A) and grapefruit (B) after lateral inoculation; lemon (C) and sweet lime (D) after stem-end inoculation.



Text — fig. 2. Sweet lime fruit 3 weeks after stem-end inoculation with *S. bataticola* from grapefruit.

Text — fig. 3. Grapefruit 3 weeks after stem-end inoculation with *S. bataticola* from Shamouti orange.

Each item comprised 10 fruits, five being inoculated into the albedo, and five into the stem-end, after removal of the button. The fruits were incubated for four weeks at 22—25°C.

All inoculations with all fruit varieties were successful. The incubation periods lasted 5—10 days in Shamouti oranges and grapefruit, 5—13 days in lemons, 6—9 days in sweet limes, and 9—14 days in Valencia oranges.

The symptoms appeared usually as a watery spot, light brown in colour, at the point of inoculation. In Shamouti oranges and particulary in Valencia oranges the symptoms appeared sometimes first at the stylar end. Within a few days the rot spread over the whole fruit, either in irregular patches or, somewhat faster, along the segments of the fruit. In all fruits except grapefruit the colour of the rotten patches turned brown, and finally the whole fruit became brown to black, after 10—28 days. With sweet limes which were overripe when inoculated, the rotting and subsequent darkening were more rapid than in other varieties, and lasted 7—13 days only. In grapefruit the transition of colour in decaying fruits was through pinkish to grey and black.

The blackish appearance of fruits is due to sclerotia scattered over the whole surface of the fruit.

In a number of fruits the core and albedo blackened and sclerotia were present on the core and on the membrane of the fruit segments.

No appreciable differences were found in any respect between the two modes of inoculation.

The above results may thus be summarized as follows.

Sclerotium bataticola Taub. from fruits of Shamouti orange and grapefruit was capable of inducing rot in fruits of Shamouti and Valencia oranges, grapefruit, lemon and sweet lime. The rots induced by both isolates in Shamouti oranges and grapefruits were similar to the naturally occurring rots.

A STARCH TEST TO AID IN THE PRUNING OF CITRUS TREES AFFECTED BY DIPLODIA

By G. MINZ

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

Pruning branches affected by *Diplodia natalensis* P. E. is essential for the control of Diplodia blight and of the stem-end rot caused by this fungus on citrus fruits. Pruning is generally carried out up to the nearest healthy branch. When severe pruning is necessary, the healthy part of each branch is so much the more valuable for the tree's recovery, and care must be taken not to cut it away.

A test enabling us to distinguish with certainty between affected and healthy parts of the branch is thus of obvious interest.

Fawcett*) has described a starch test for the diagnosis of Quick Decline in citrus trees, a condition he found to be associated with disappearance of starch from the roots (of sour orange stock).

In a systemic disease like Quick Decline, the depletion of starch reserves could thus be traced to the roots. But in Diplodia blight, which constitutes a local infection of branches, spreading basipetally, we did not find the roots of affected trees depleted of starch (on sweet lime stock).

Applying in 1945 the starch test (IKI) to the cut surface of branches of Shamouti orange we established that branches killed off and dried by the fungus are devoid of starch. Beyond the dead part of the branch there may follow a part where starch appears gradually, the cut surface staining irregularly with IKI. Further on, the healthy parts of branches are filled with starch and stain deeply over the whole surface cut.

Cultures made from those parts of branches in which starch disappeared gradually, mostly revealed *Diplodia*. Cultures made from the healthy tissues were almost always negative. In rare instances, when *Diplodia* was isolated from this tissue, its presence was limited to 15—20 cm. only beyond the point on which the starch test begins to be positive.

The correlation between the presence of *Diplodia* in tissues and the gradual disappearance of starch might be taken to indicate that the depletion of starch reserves is a result of the carbohydrate utilization by the fungus.

The starch test could be used as a guide in pruning affected Shamouti orange trees to eliminate *Diplodia*.

PEACH POCKET

By G. MINZ

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

In 1946 the author found at Rehovot for the first time in Palestine *Taphrina deformans* (Berk.) Tul. attacking peach fruit of the C. O. Smith variety. The disease assumed the form of a shallow outgrowth (with a fungus layer) over one side of the fruit.

---

*) Fawcett, H. S. (1945). A starch test for Quick decline. — *Calif. Citrogr.* 30 : 122.

In 1949 epiphytotics of leaf curl occurred on various varieties of peaches, but not of nectarines, throughout the country. Fruits of the C. O. Smith variety were again found infected by *T. deformans* in the author's orchard at Rehovot. In this year the fruit grew to be misshaped (cf. text-fig. 1) much like plums affected by the pocket disease caused by *T. pruni* (Fuckel) Tul.

Text-Fig. 1. On the right: peach fruit misshaped by *Taphrina deformans*. On the left: healthy fruit.

REMARKS ON Dr. H. R. OPPENHEIMER'S ARTICLE: „NATURAL REPRODUCTION OF EXOTIC PLANTS IN PALESTINE"

(Summary of the note in the Hebrew section of this issue)

By U. FELDMANN

In addition to those mentioned by Dr. Oppenheimer, some further cases of spontaneous germination are described, as *Eucalyptus rostrata*, on the banks of Wadi Musrara, Persian Lilac, grape and citrus seedlings in yards at Tel Aviv, Oleander in the Surek Valley (Judaea) and in certain wadis of Samaria, and *Ricinus* almost everywhere. Some cases had already been mentioned in a previous article of this author.

Carob tree seedlings cannot survive the dry summer months in the coastal plain, while spontaneous Aleppo pine seedlings have been observed in the Herzl forest at Ben Shemen.

The author thinks that cones of *Araucaria excelsa* are found rarely as most specimes have not yet reached the requisite maturity. He assumes that cones are not produced before the age of 14—15 years.

REDCLIFFE N. SALAMAN

(On his 75th birthday)

Recently Dr. Redcliffe N. SALAMAN reached his 75th year. Few investigators can look back to such a lifetime of achievement. His name is connected with one of the most important staple foods of mankind — the potato — and few people have done as much towards the improvement of its cultivation as he has: directly, by his own work and by associating with himself such first rate investigators as Kenneth Smith and others; and indirectly, by stimulating and encouraging potato investigation in other parts of England and the British Empire. It is due chiefly to him that Britain's potato research has achieved such a notable reputation and that her potato industry has attained its present high standards. His village, Barley, north of Hearts not far from London, has become famous as the site of his extended experiments begun in 1906 and carried on until recently. Barley was the Mecca for all investigators of potato cultivation. His house was a centre of social life and of the arts, thanks to his wife, a well-known poetress and writer.

R. N. S. was educated at St. Paul's School and Trinity Hall, Cambridge, as M. D. Cantab. His original field of research was pathological medicine; for three years, from 1901—1904 he served as Director of the Pathological Institute of the London Hospital until illness interrupted his medical activities.

The two years of ill-health and consequent idleness which followed were of incalculable value, both to R. N. S. and to the cause of Science, for during this time his mind was occupied with the eternal problems of life and the means of penetrating to the depths of their riddles. It was the period of the rediscovery of the fundamental rules of heredity which bear the name of a non-professional explorer — the Czech priest Mendel, whose heritage is now dividing the scientific world into opposing camps — and R. N. S. felt that a new world had opened to his researching spirit. He decided to leave medical pathology which could at best lead only to the discovery of small channels of knowledge concerning the human body, and to follow the great rivers of exploration into the hidden laws of all life and evolution.

He was fortunate in finding, in the British champion of genetics, Sir WILLIAM BATSON, a friend to inspire and guide his venture into this new science. He turned first to genetical work on animals but this, he soon realized, did not appeal to him, and it was not until his gardener, IVAN JONES, proposed that he turn to the study of that humble vegetable, the potato, that he found his destined field for research.

From this point, his life work may be divided into three sections: (1) the period from 1906 when he was carrying out independent experiments at Barley and working voluntarily under

various auspices for the general benefit, until 1926 when he was nominated Head of the Potato Virus Research Station at Cambridge; (2) his work at the Institute and his practical activity in the Potato Advisory Committee; (3) his retirement in 1939 when he began writing his classic work on the potato, an undertaking which was to occupy the next nine years.

During the first period two dangerous diseases of the potato threatened the crop, not only in Britain but throughout Europe, with destruction. These diseases were Blight (*Phytophthora infestans*), famous for its devastation in 1845—46; and Wart Disease (*Synchytrium endobioticum*) which first appeared in 1876 and which made such inroads in 1907 that the British Board of Agriculture assigned a special inspector, G. C. Gaugh, to investigate this problem. A year later, in 1908, Gaugh made a discovery which proved to be of general import — and which was decisive for the work of R. N. S.

On visits to the invaded potato fields, Gaugh had noticed that several varieties remained immune; he immediately inaugurated a Wart Testing Station to determine which varieties were susceptible and which immune. But soon an impasse was reached due to the confusion reigning over the nomenclature. To give only one example: the variety Up-to-Date was known by two hundred different names in various regions. A special body, known as the Potato Synonym Committee, was therefore set up by the Royal Horticultural Society to clear up this muddle, so that the work of testing the resistance to Wart Disease could go forward. R. N. S. was a member of the committee and in 1919, after the death of its first chairman, J. Snell, he was elected to this post.

His work in this committee had three important results: (1) He undertook the first fundamental study of the morphology of potato varieties, an intricate task, which however furnished him with the unique knowledge which makes his Text-book "Potato Varieties" (Cambridge, 1926) so fundamental a work. (2) He succeeded in eradicating the synonymity of the varieties grown in the British Isles. (3) He discovered, in 1908, a genetic resistance to *Phytophthora infestans* in the seedlings of a wild potato, *Solanum edinense*, which retained its resistance for seventeen years at Barley. Extensive hybridisation between these immune seedlings and domestic varieties, followed by selection of suitable types, was carried out by R. N. S. until 1926, when the stocks were transferred to the new Potato Virus Research Station at Cambridge (Salaman and Lesley, J. Genetics, 13: 177—86, 1923). By that time, R. N. S. possessed seedlings of over a score of varieties endowed with good economic characteristics and apparently immune to blight. Some of these have been grown for many years in Ireland and have retained their resistance, though a few were attacked by blight in 1938. R. N. S. suspected that the attack might be due to the appearance of a new biotype of blight and this was confirmed by a member of the Potato Virus Institute, Miss

O'Connor. New strains immune to these biotypes were obtained and after the retirement of R. N. S., this work was continued by other members of his Institute.

With the assumption of the directorship of the Potato Virus Research Institute his major activity on virus diseases commenced.

His first important work in this field was an analytical study of the virus, Crincle A. originally described by MURPHY (Proc. Roy. Soc., B 741, 50:1929). This study led to the discovery of a new virus disease, Para-crinkle (Salaman with Le Pelley; Proc. Roy. Sa., B, 742:140—175; 1930). The King Edward variety, though healthy in appearance, was found to harbour the disease; inoculation from King Edward to President produced no visible symptoms in the latter, but when the disease was then transferred from President to Arran Victory, this variety was severely infected.

Further work with the same method enabled him to differentiate between to strains of the virus disease, — Streak "A" and Streak "B". The first is latent in the Up-to-Date potato; when transferred, it produces Streak in both the Arran Victory and the President varieties. Streak "B" is latent in the Di Verron potato; transferred to the Arran Victory it causes only a mild mosaic; but when transferred from the latter to the President, a lethal infection develops (Nature 126:24, 1930).

The existence of virulent viruses in plant carriers enabled R. N. S. to discover the possibility of immunising plants against the attack of several virus diseases. By inoculating with a mild type of X virus and then reinoculating with the most necrotic strain of this virus, complete immunity from any further attacks of X virus was obtained. (Nature, 131: 468, 1933).

He produced similar results with the Y virus, isolating it from *Schizanthus,* transmitting through tobacco plants, and thus receiving a weakened strain which immunized tobacco against further infection by the normal Y virus. However, the Y virus was insufficiently attenuated by this method to confer similiar protection to potatoes. By special culture and transfering methods he was later able to secure more attenuated strains which protected both tobacco and potato plants. (Nature, 139: 924, 1937.)

In a later study he showed that the protective effect appears only after the first mild strain has established itself in the plant which occurs five days after inoculation. A re-inoculation before this period has passed has little or no immunizing effect. (Phil. Trans. Roy. Soc. B 229; 137, 1937.)

In his search for attenuated strains of the viruses, R. N. S. endeavoured to develop special methods for their differentiation. In that connection, his study on strains of X virus is noteworthy for its originality of approach and experimentation. He distinguished six strains of this virus on the basis of inoculations in a wide range of plants under constant conditions of temperature and high humidity.

He found that the weaker strains, without exception, protected against the more virulent strains. The protection was specific to strains of Virus X but weaker strains of Virus X did not protect against more virulent strains of virus Y. This was due, according to him, to the existence of radicals common to nearly related forms which determine the attachment of the virus molecule to the plant protoplast and prevent subsequent attachment of a second related strain as all the available supplies are taken up by the first invader. The radicals may be determined by antigens. (Phil. Trs. Roy. Soc., B 229: 137, 1938.)

But Salaman's most important practical activity was in his efforts to secure virus-free potato stocks by selection, hybridisation and cultivation of the plants in locations safe from insect infection. As active Chairman of the Potato Advisory Committee of the National Institute of Agricultural Botany he launched a scheme for the cultivation and distribution of virus-free stocks of standard varieties; a work which is now firmly established under the aegis of the National Institute of Agricultural Botany and, we understand, is distributing over two hundred tons of healthy stocks yearly. Great Britain is thus unique in the possession of such a reserve of healthy potatoes, which secures the industry and its ability to sell healthy seeds to other countries.

The ten years following his retirement in 1939, he devoted chiefly to the writing of his *magnum opus*, "The History and Social Influence of the Potato". But even during this time he worked tirelessly to find new locations in which the cultivation of virus-free potatoes might be safeguarded; for this purposes he visited the Hebrides and the Isle of Isley. During the war he did not cease pressing the authorities to accept the scheme which he had first laid before the Empire Marketing Board in 1934, embodying his principles for the commercial production of virus-free stock seeds. Only in 1941 did the National Institute of Agricultural Botany decide to put his scheme into practice.

The great achievement of this period, however, was the historical treatise on potato cultivation; its origin, its introduction to Britain and its influence on the social stratification of the Old World (Cambridge, 1949). Such a wealth of diversified information on archeology, the arts and economics is accumulated in this book that one wonders at the ability of one man to embrace such a breadth of scholarship. He showed how the introduction of the potato, which on the one hand benefitted mankind as a new source of cheap food, was on the other hand used by the possessing classes as a means of exploiting the labouring masses by lowering their wages. The words of the great British economist, Clapham: "Sympathy with wretchedness is the sign of a generous mind", quoted by R. N. S., could well be applied to him, for he endeavoured all his life to benefit mankind by safeguarding one of its most important food sources, and to secure the labouring classes a full share in these benefits.

The gentle and socially-conscious heart of R. N. S. brought him close to the suffering people of the British Isles. Occupied as he was with scientific research, he nevertheless served for forty years as Justice of the Peace and for twenty-five years as Chairman of the Bench and Chairman of Local Councils for a number of years. During the first World War he served as a Captain in the Jewish Brigade, being 2nd in command under Col. Patterson, Commander-in-Chief of the Gallipoli Expedition. During the second World War he was Lieutenant in the Home Guard.

R. N. S. never forgot his Jewish origin and was actively interested in promoting social and literary activities among his people in England, serving as President of various Jewish societies of literary and social character. His military service in the Near East Army interested him in Palestine; he wrote a book on this country (Palestine Reclaimed, 1920) and was one of the devoted friends of the Hebrew University, serving as Governor of the Board. He was also most helpful from the beginning in the publication of our Journal.

On the occasion of his 75th birthday, we wish to add our voices to the choir of his admirers, wishing him good health and success in the final summation of his work, on which he is now engaged.

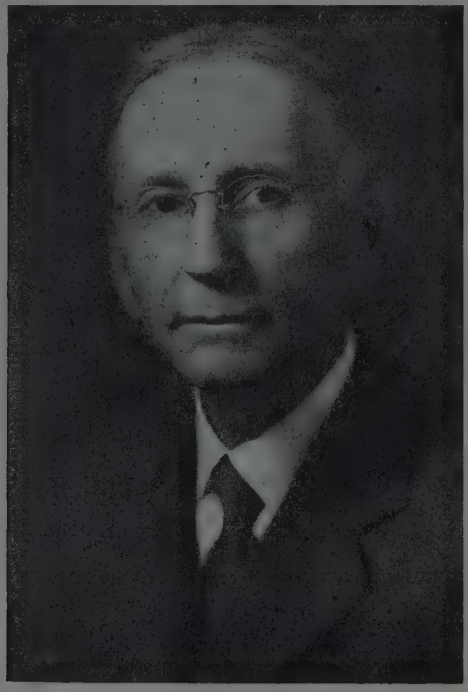
I. REICHERT.

H. S. FAWCETT

1877—1948

(Appreciation and Memories)

Since the appearance of the last volume of our Journal, Prof. H. S. Fawcett, the greatest citrus pathologist of our time, has passed away. His death, on December 12th, 1948 in Riverside, California, was a great blow to his many friends and admirers in Israel, for he had been well known here since his first visit in 1930. His standard work on citrus diseases, in both the Hebrew translation and the



English edition, is to be found on the bookshelves of every citrus grower; his warmth of personality and readiness to help and advise won him the love and admiration of all who came in contact with him in the course of his visits to our country.

Fawcett created the study of the pathology of citrus plants, and he inspired, by his work, suggestions and guidance, citrus plant pathologists in all parts of the world; every known citrus disease has at one time or another passed under his scientific scrutiny. His text

book on citrus diseases, *"Citrus Diseases and their Control"* (1936), is the most thorough work ever undertaken on a single group of plants and may serve as a classical model for future plant pathological monographs. It is not merely an accumulation of data on the morphology of the diseases and their causal organisms plus recommendations for control measures as is the case with most text books of that time. Its plan is original and one feels the creative spirit infusing every page, for his exposition of the mass of material gathered by him and by others in the field is a truly creative synthesis. It is unique for its exactness and for the fact that all existing knowledge of citrus diseases, in all languages, was critically screened and incorporated into the book. Its outstanding feature, however, is the accumulation of ecological data included in the small chapters entitled "Contributing conditions". These descriptions of the *modus vivendi* of citrus diseases enable the reader to know under which circumstances a specific disease may appear or retreat and thus use the recommendations at his own discretion.

When Fawcett began his investigations in 1912, nothing exact was known concerning the pathology of citrus. The only information available at the time consisted of the mycological studies of O. Penzig and the studies of O. Comes and L. Sevastano in Italy. The latter wo held that gummosis disease of citrus was caused by a bacterium. In spite of the fact that Fawcett, in 1913, proved gummosis to be caused by a fungus, *Phytophthora citrophthora*, L., Sevastano continued to publish papers on the bacterial nature of gummosis and its identity with gummosis disease of stone fruits. He reiterated this belief as late as 1921 when I visited him in Acireale. It was not until 1925 that Petri confirmed the findings of Fawcett and finally destroyed this old belief in Italy.

Fawcett's second great research achievement lay in the ecological approach he applied to the investigation of plant pathology in general and of citrus diseases in particular. At the time when L. R. Jones, in Wisconsin, was evolving new methods of approach to the ecological investigation of plant diseases, Fawcett, at Johns Hopkins University, was studying the relation of temperature to the development of the *Phytophthora* species responsible for gummosis of citrus, working under the guidance of the famous plant ecologist, Prof. B. E. Livingston. The publication, in 1921, of the results of this work: *"Temperature relations of growth in certain parasitic fungi"* (Univ. Cal. Publ. Agr. Sci. Ser. 4:283—332) may be considered a milestone not only in the field of citrus pathology, but in the broad terrain of plant diseases in general, for he demonstrated, that ecology can be used succesfully in the study of plant diseases.

This interest in ecology, inspired by his mentor, was a decisive factor in Fawcett's work, for it impelled him to study, at first hand, the ecological background of citrus diseases throughout the world. He visited the Mediterranean countries and South America but did

not succeed in reaching India and Southeastern Asia, though he was particularly interested in the latter. In India, he had hoped to solve the riddle of the origin of the *mal secco* disease, as he suspected that its source lay there. This part of the world is the only white spot in his book; in describing the disease occuring in these countries, he was compelled to rely on the older studies of Lee, Reinking and others.

His discovery of the causal organism of *Psorosis* and his work on the agents of other virus diseases of citrus was, however, the most notable and productive chapter in his scientific career, and during the last fifteen years of his life he became entirely absorbed in the citrus viruses. The sudden realisation of the nature of *Psorosis,* after twenty-seven years of hard work on it to no avail, was dramatically described by him in his Faculty lecture in 1940. "It was like a flash of clear light after twenty-seven years." "It was as if the eyes of scientific workers in this subject were looking through mine." "The hypothesis seemed logical — that it should be a fungus or bacterial disease of some kind." And then suddenly "in that moment a completely new hypothesis took the place of the old one." His old friends, the fungi and bacteria, had failed him and he turned his main interest to the viruses. He saw in the realm of these organisms the clue to all the undeciphered diseases of citrus, and this assumption proved productive. Thus, he identified the causes of the stubborn disease of sweet orange, wood pocket of lemon, *exocortis* of trifoliate orange, and quick decline of orange trees.

Fawcett was not only a great investigator, but also a great moral personality — a rare phenomenon nowadays. I was privileged to be close to him during some months in 1930 when he visited Palestine and this friendship was continued by correspondence until his death.

The sources of his great personality were twofold: first, his great love for nature and for mankind and the human spirit as manifested in each individual. A fragment from a letter to me (27.6.1930) from Geneva answers the question as to why he was so attached to nature. "What induced me to study natural history? It came, I suppose, from the great love of nature. I was born into in the country. My mother taught me about flowers and birds; my older brothers were fond of the woods; my father was especially interested in geological things. Then, in preparatory school a teacher interested in biology (now Dr. H. S. Conard of Grunell College, Iowa) got me especially interested in the low forms of life, fungi, algae and bacteria."

The second important source of his character was his belief in the divine origin of the human soul: "God created man in his image" and consequently he championed the interests of the poor and unfortunate. Thus, he spared time to serve in the Friends' Service Committee mission to famine-stricken areas of southeastern Russia

in 1922—23. His modesty and humility I can only describe as "Mosaic", in the sense which the Bible tells of Moses, "Now the man Moses was very meek, above all the men which were on the face of the earth." In one of his letters to me from Italy (27.1.1930), in reply to my mention of the high esteem in which he was held in our country, and the impression he left behind him, he writes: "I fear from what you have already said about me that you do not know or realise the other side, the weak points which I know so well myself, but which I have perhaps learned now to hide. *I have too much of a reputation to properly live up to already without having it increased.*" Such humility, it seems to me, can only be compared to that of Moses in ancient times, or, more recently, to St. Francis of Assisi, or to one of our Hassidic rabbis.

His way of life led me to admire the great religious power of the Quaker movement of which he was a member, and which reminded me strongly of our Jewish Hassidic movement as described by Martin Buber. Thus, in addition to our scientific cooperation, Fawcett and I discovered a common ethical and religious ground which strengthened our friendship still more. In a letter to me from Rome (12.6.1930) he writes, "..... the personal attachment is mutual, for I found a common ground of ideals and principles with you: to seek to live these as a 'Way of Life' ourselves and to stimulate the same in others is the great end in life, is it not?" He was seeking to find for us both a final common religious basis and tried to interest me in a religious statement "made by a committee composed of prominent College-men in the U.S.A. to the scientifically minded." He found in our country a new free approach to religion which appealed to him. He always remembered his philosophical and religious talks with one of our prominent citrus growers, Mr. T. Miller, to whom he always sent his kind regards in letters to me. On his return to California, I gave him a copy of Dr. J. Klausner's book, "Jesus of Nazareth" which pleased him exceedingly.

Religion, for him, was free of prejudicies or superstitions. When he and his family went to Nazareth to visit the Christian shrines there, he himself declined to enter the shrines, saying to me, "..... we Friends are close to God in a mere room." His religion was the real love preached by the Judaean Prophets.

He was admired and beloved by all our farmers and citrus growers. His first lecture at the Great Hall of the Hebrew Gymnasium in Tel-Aviv, attended by many hundreds, will never be forgotten by those who were privileged to attend. It was apparent to all that Fawcett was not merely giving a scientific lecture, but was keenly aware that he was delivering a discourse in the Land of the Bible and trying to revive the destroyed House of Israel. He was a real friend of the return of the Jewish people to Palestine. In a letter from Geneva, (21.1.30) he writes, "I have had a number of occasions to speak of the wonderful work the Jewish people is doing in Palestine to those I have met since leaving Palestine, and I shall

continue to do so, so that the truth may be known." When he returned to California, he lectured in various circles and wrote in various papers, especially in the Friends' Press, about the revival of Palestine.

Palestine signified for Fawcett something more than a mere citrus-growing country; it was the Holy Land, the local names of which were carved into his memory from early youth by his frequent reading of the Bible. He was doubly delighted, therefore, when on one of his visits he was able to fix the history of citrus fruit in this part of the world by the help of Holy monument. For it happened that when Fawcett visited the 2000-year-old Synagogue at Capernaum, where Christ is said to have visited and prayed, he discovered in the excavations a panel of stone on which citron and lemon fruits were carved, thus proving "that they were grown in Palestine 1900 years or more ago."

He loved the Bible and considered it the greatest source of humanism; he was therefore a great friend of the people who had created this great Book. In his letter from California (23.5.34) he writes, "I am often reminded of Palestine and the very pleasant time I had there with you. The little Hebrew Bible which the growers gave me when I left Palestine, stands on our table at home as a reminder of the pleasant associations I had in Palestine." Our Battle for Freedom in Palestine weakened our correspondence, but when peace came I wrote him describing all the pleasant new events and developments which had taken place, knowing he would rejoice with us and look upon them as a fulfillment of the Divine promises to the Jewish people. My letter never reached him; he had died some days before.

He will be remembered by new Israel for his friendship and guidance; as a great scientist and a great man.

I. REICHERT.

RACHEL YOFFE-ROGOFF

Mrs. Rachel Yoffé-Rogoff who died in October, 1947 in Haifa at the age of 70, was the first learned botanist who settled in Palestine.

She arrived for the first time in this country from her native town Simferopol in the Crimea as early as 1892, settling at Tiberias where her brother, Dr. Hillel Yoffé, well known for his studies on the malaria fever in Palestine, was then working as a general practitioner. In 1894, she proceeded to Montpellier (France) to study botany. Here, CHARLES FLAHAULT became her teacher. She acquired a thorough knowledge of the Mediterranean plant world and, at the suggestion of her teacher, specialised in *Algae*.

After her return to Palestine, she earned her living at Jaffa, teaching science in the Girls' School of the Alliance Israélite Universelle. From the beginning of the present century, she collected a great number of plants in cooperation with AARON AARONSOHN who won his spurs as an expert on the flora of Palestine under her guidance. Her rich private herbarium, still consulted by A. EIG in the twenties of our age, is unfortunately lost, since she neglected her scientific studies after her marriage to the architect Mr. BENZION ROGOFF. However, many duplicates are preserved in the Herbarium A. Aaronsohn and probably in the Herbarium of the University of Montpellier where her generally excellent determinations were checked.

We do not know whether she published any scientific papers, but her contribution to the botanical exploration of Palestine and specially the Galilee, and her cooperation with AARONSOHN deserves emphasis from a phytohistorical point of view.

H. R. OPPENHEIMER

FILIPPO SILVESTRI

On June 6th 1949 passed the great entomologist Filippo Silvestri. His many-sided scientific activities furthered general biology, as well as theoretical and agricultural entomology. He was an indefatigable worker and excellent teacher, honest, modest and unpretentious — all his aspiration being concentrated upon unselfish scientific research. Famous at home and abroad, he was honoured by Italian and foreign academies. He published not less than 468 scientific papers.

From 1904, he devoted his energies to applied entomology, studying the noxious insects of agriculture, horticulture, and silviculture. Peasants appreciated his services to agriculture so much that they called him "il Mago" (magician). Whenever he was informed of an outbreak of a post, he immediately hurried to the scene in person, organizing the measures for its eradication. Besides applying chemical and mechanical means of control, he devoted much zeal to the biological methods. Thus, he brought parasites for the control of Pseudococcus Comstockii from Asia, Africa and the Americas. His studies on the Olive and Mediterranean fruit-fly and various scale insects and grasshoppers deserve amphasis. In his laboratory at Portici where he worked during many years, he educated numerous pupils of Italian and foreign origin.

Professor Silvestri was a devoted friend of his pupils, always ready to help, advice and encourage. His relations with the entomologists in Palestine were close and cordial, and proved helpful in many cases. Living up to 76 years, he preserved his mental capacities to the last day, working even on his death-bed. His memory will be precious to all who had the privilege to know him.

Dott. SARAH ZIMMERMAN—GRIESS

"YAKHIN-HAKAL"

ACTIVITIES IN 1949/50

1. *Cultivation of Citrus Groves*:
"Hakal" Agricultural Contracting Co. Ltd. (Founded by Yakhin & Pasa). — Cultivation of 14.500 dunams of groves situated in 21 settlements and owned by 522 people.
"HAKHAL-YAKHIN" — joint cultivation of 12.000 dunams of groves appertaining to the Custodian of Abandoned Property.

2. *Vegetable Growing Nurseries*:
"HAKAL" Vegetables Ltd. — cultivates 4200 dunams situated in 8 settlements; additional 5000 dunams in 9 settlements are under scheme. The latter are planned as follows: 3600 d. vegetables; 1000 d. seeds; 400 d. nurseries.

3. *Citrus Fruit Marketing*:
"YAKHIN" Agricultural Cooperative Association Ltd. — exported during the 1949/50 season 600.000 cases of fruit & supplied 13.500 tons of fruit for local consumption. The above mentioned quantity of citrus fruit represents 15% of the total quantity marketed by the Citrus Marketing Board of Israel.

4. *Citrus Fruit By-products & Vegetable Preserves*:
"YAKHIN" Canning Co. Ltd.: 6200 tons of citrus fruit were used for concentrates & juices for export. The local market was supplied with sweetened juices, jams & vegetable preserves.

5. *Agricultural Settlements*:
"YAKHIN" Middle Class Agricultural Settlement: — organizes and prepares for persons with private means, agricultural settlements on a total area of 20.000 dunams of Jewish National Fund land.

Summary: The current year's turn-over of the affiliated undertakings amounted to 2.250.000.— I. P.; and approximately 2000 workers were employed during the year.

Head Office: Lilienblumstr. 48, Tel-Aviv, Israel, Tel 4365/4158.

HAMASHBIR HAMERKAZI

COOPERATIVE WHOLESALE SOCIETY LIMITED

Head Office:
Tel-Aviv, Hamashbir Bldg., Salameh Rd., P.O.B. 130, Tel. 6011-16

Branches:
Haifa: Hamashbir Bldg., Harbour St., P.O.B. 295;
Jerusalem, P.O.B. 438

LARGEST TRADING ENTERPRISE IN ISRAEL

SALES DEPARTMENTS :

Groceries - Feeding Stuffs / Grains & Cereals / Seeds / Chemicals-Fertilizers / Agricultural Machinery — Tools & Implements / Dairy Equipment / Pumps / Industrial Equipment / Engineering Supplies of every Description / Fishing & Fish-Breeding Equipment / Building Materials / Fuel & Lubricating oils / Textiles & Footwear, etc. / Stationery & Writing Materials / Household & Kitchen Utensils

TRADE SUBSIDIARIES:

HAMASHBIR IMPORT-EXPORT APPROVED ASSOCIATION LTD.
HAMASHBIR LA-TZARKAN LTD.
HAMASHBIR ZIDON LTD.
LAYAM LTD.
HABAR LTD. —
BONDED WARE-HOUSES

FINANCE SUBSIDIARIES:

HAMASHBIR HAMERKAZI (FINANCE & INVESTMENT) CO. LTD.
CONSUMERS CO-OPERATION FUND LTD.
HENRIETTA SZOLD KITCHEN FUND
OSHYOT LTD.
SMALLHOLIERS' VILLAGES CONSUMERS' CO-OPERATION FUND

INDUSTRIAL ENTERPRISES:

'SHEMEN' PALESTINE OIL INDUSTRY LTD.
HAMASHBIR MILLS
SEED CLEANING PLANT
MIN'AL LIMITED
HATZAMAR LTD.
"LAHMENU" LTD.
'HAKHAYAL' LTD.
FOODSTUFF PACKING PLANT
REPAIR SHOOPS FOR TRACTORS, MOTOR CARS AND ALL AGRICULTURAL MACHINERY

PARTICIPATING in:

HAMGAPER LIMITED
PALESTINE PORTLAND CEMENT WORKS
"NESHER" LTD.
FERTILIZERS & CHEMICALS LIMITED.

יוסף צבי דמסט הי"ד

י. צ. דמסט ז"ל, שסכום מחקרו בתפוחי עץ מההר והעמק מתפרסם בכרך הנוכחי, היה בוגר המכון ללמודי החקלאות ברחובות, בן המחזור השני. הוא נולד בפולין, בשנת 1920, למשפחה חרדה מטרנוב. אהבת התורה והשאיפה לעבודה חקלאית בא"י היתה מושרשות עמוק בלבו. אחרי למוד בגמנסיה עברית, עלה בשנת 1940 ונרשם כתלמיד האוניברסיטה העברית. היה מחונן בכשרון להוראה, לימד טבע בעיר העתיקה של ירושלים ובסמינר למורים דתיים שבתל־אביב. שאיפתו להתישבות בהרים הניעתו להתמסר לענף המטעים, ולפי כך בחר בגדול תפוחים כנושא לעבודת הגמר שלו.

אחרי סיום חוק למודיו בשנת 1947 עלה לכפר עציון כחבר הקבוץ שאת אחת מבנותיו בחר לו לאשה. אך זמן קצר הספיק לעבד במטעי המשק, כי כוחות אדירים של האויב עלו על קומץ המגינים של הגוש, סמוך לסיום תקופת המנדט. דמסט לחם בעוז וקיפח את חייו בקרב.

יוסף היה ענו, שקט, טוב־לב, נח לבריאות, נבון, מתמיד, נאמן לחבריו ולמפעלו. אדם שלם היה, שלם עם האדם, שלם עם בוראו, שלם עם המפעל שלמענו לחם ועם היעוד אשר התוה לעצמו. זכרונו לא ימוש בקרב מוריו, חבריו וידידיו לעד.

אחד מחבריו

לחייהם. ואין התופעה הזו צריכה להפתיענו אחרי שאנו יודעים המון צמחים בארצנו המתחילים לתת את פירותיהם בגיל של 5—6—7 שנים ואף של 10—12 שנים ויותר.

7) נבטי הקקיון *Ricinus communis*, מי לא ראה אותם בהמוניהם בארץ? הם נובטים לעתים קרוביות במאותיהם מתחת לצמח האם, אשר ממנו נשרו הזרעים. הם גדלים בצפיפות כזו שהם מוכרחים למות אחרי זמן קצר, ורק בודדים נשארים בחיים. הנשארים צומחים יפה ועולים ופורחים ונותנים פירות בשפע.

8) נבטי החרוב: יש בחצרי שני עצי חרוב (מהם אחד בעל פרחי נקבה) והזרעים נובטים שנה שנה במספר לא קטן. אבל בתנאי שפלת החוף הם אינם יכולים לעבור את יובש הקיץ ואינם זוכים להתקיים עד עונת הגשמים הבאה. יתכן כי בהרי יהודה או במדרונות הכרמל הם נובטים ומתקיימים וגדלים.

9) נבטי אורן ירושלים (*Pinus halepensis*). לא נזכרו במאמרו של א.: וכן לא נזכרו נבטי הצבר (*Opuntia Ficus indica*) וכמה אחרים. את נבטי האורן ראיתי בשפע בבן־שמן: ביער הרצל, ויש לי הרושם — כמעט הבטחון — שהנבטים הללו גדלים ומתפתחים ונותנים במשך השנים עצים.

ד"ר רדקליף נ. סַלְמַן, בן 75

המחקר סוקר את חייו ואת מפעלו של החוקר היהודי המפורסם שהקדיש את רב מרצו להדברת המחלות של תפוחי האדמה.

ו. ריכרט

ה. ס. פוֹסְט ז"ל

ניתנה הערכה של עבודת חייו ואישיותו של הפרופיסור ה. ס. פוסט, המומחה הידוע במחלות ההדרים ששהה גם בארץ ונפטר בקליפורניה בדצמבר 1948.

המאמר יופיע במלואו בעברית במקום אחר. י. ר י כ ר ט

רחל רוגוב ז"ל

הגב' רחל רוגוב, אחותו של ד"ר הילל יופה ז"ל, היתה הבוטנאית הראשונה בארץ ישראל. היא למדה את המקצוע במונפליה שבצרפת והקימה מעשב גדול שרובו נאסף בשותפות עם אהרן אהרנסון ז"ל.

ה. ה. אופנהיימר

פרופ' פיליפו סִילְוֶסְטְרִי

פ. סילוסטרי שמת ביוני 1949, היה אחד האנטומולוגים הגדולים בעולם, חקלאי מובהק ומחונן בתכונות אופי יוצאות מהכלל. קשריו עם חבריו ותלמידיו בארץ היו אמיצים ולא פעם הגיש להם את עזרתו.

ש. צימרמן־גריס

הערות אחדות למאמרו של ד"ר ה. ר. אופנהימר:
Natural reproduction of exotic plants in Palestine"[1])

מאת אוריה פלדמן

רביתם הטבעית של עצים ושיחים או מטפסים רב־שנתיים (כפי שמנסח ד"ר ה. ר. אופנהימר) מהוה פרובלימה חשובה מאד, הן מבחינה הורטיקולטורית והן מבחינה יערנית. ויש לציין שרק מעטים מבין הגננים והחקלאים טפלו בברור פרובלימה זו. וכפי הנראה, נעלם משימת־לבו של ד"ר אופנהימר מאמרי: „צמחי בר זרים בצמחית א"י"[2]), אשר בו נסיתי גם אני (כמדומני, לראשונה) לעמוד על אותה פרובלימה עצמה.

כיום הזה, לאחר שד"ר אופנהימר פתח מחדש בברור הענין, אשתדל להוסיף כמה עובדות ולתקן כמה פרטים בלתי מדויקים שנתגנבו לתוך המאמר.

1) על האוקליפטוס כותב ד"ר אופנהימר: הרביה הטבעית של אוקליפטוס מצויה בתור יוצאת מן הכלל". אמנם הוא מציין מקרה אחד של נביטת *E. camaldulensis* בסביבת חדרה. במאמרי הנזכר לעיל ציינתי נביטה וגדילה של שתילי *E. rostrata* (=*E. camaldulensis*) רבים בחוף המוסררה.

2) האזדרכת *Melia Azedarach* נמנית על הצמחים, אשר זרעיהם נובטים בנקל בסביבות רחובות, אבל לא נזכר אם הם הגיעו לגיל של עצים בוגרים. עלי לציין, (ואני מזמין את המעונינים להוכח בכך) שבחצרי בתל אביב (ברחוב מנדלי מ"ס 4) גדלות כמה אזדרכות שנתפתחו כצמחי־בר (לגמרי בלי כל טיפול) מזרעים שנפלו מן האזדרכת היחידה שנטעתי לפני 25 שנים. זו האחרונה נותנת זרעים רבים מאד והללו (כפי שמציין בצדק ד"ר א.) נושכים אליהם המוני בלבלים. הצפורים ניזונות מציפת הפרי ומסייעות להפצת הזרעים. מידי שנה בשנה נובטים בחצרי עשרות שתילי אזדרכת ואני עוקר אותם כדי לפנות מקום לצמחים אחרים.

3) צמחי הגפן *Vitis vinifera* מופיעים שנה־שנה בהמוניהם בחצר ביתי, ואני עוקר אותם באופן שיטתי.

4) צמחי הציטרוסים למיניהם גם הם מתפתחים אצלי בשפע (מהגרעינים המושלכים החוצה) ותמיד יש צורך לעקרם.

5) על שתילי ההרדוף (*Nerium Oleander*) כותב ד"ר א. כי „הם נובטים רק במקומות לחים ומוצלים". אם לגבי הרטיבות הרי אין כל ספק בכך, כי ההרדוף גדל כידוע במקומות לחים. אבל במה שנוגע לצל, הרי כל המכיר את התנאים האקולוגיים בארצנו יעיד כי שורות ארוכות של הרדופים מצויות במדרוני ההרים, במקומות שאין בהם זכר לצל (למשל, בנחל שורק בהרי יהודה, וכך גם בכמה נחלי אכזב בהרי הגליל והשומרון).

6) פרט מענין הם פירות ה־*Araucaria* א. כותב שראה את פירות העץ הזה ברחובות בפעם ראשונה בשנת 1946. אם זכרוני אינו מטעה אותי, ראיתי גם אני את פריות הארוקריה בפעם הראשונה באותה השנה, או שנה, שנתים לפני זה. אבל ברור הדבר שהעצים האלה הניבו את פירותיהם בפעם הראשונה לא מפני התנאים האקלימיים החדשים; קרוב לודאי כי הם בכלל, — גם בארץ מולדתם — מביאים את פירותיהם בפעם הראשונה בגיל של 15—14 שנים

---

[1]) עתון לבוטניקה, סדרת רחובות, VI, 1—2, 1947.

[2]) „הטבע והארץ", כרך ד', חוברת א' (יוני 1937).

קשיון הבטטה כמחולל המוכשר לעורר מחלה בפירות הדר שונים

מאת ג. מינץ וי. גוטר

קשיון הבטטה (Sclerotium batatícola) שבודד מתפו"ז שמוטי ומאשכוליות יכלה לחולל רקבון בפירות תפו"ז שמוטי וולנסיה, אשכוליות ולימון חמוץ ומתוק. הרקבונות שנגרמו ע"י שני הגזעים משמוטי ומאשכוליות היו דומים לרקבנות שהופיעו בטבע.

קביעת מציאות עמילן כעזר בגיזום עצי הדר נגועים בכמשון הדיפלודיה

מאת ג. מינץ

הגיזום הוא הכרחי במלחמה בכמשון הדיפלודיה. כדי לתת לעצים אפשרות לחדש את נופם אין להפריז בגיזום, ולעשותו במדה הדרושה. בדיקה אשר בעזרתה אפשר בנקל להבדיל בין החלקים הבריאים והנגועים של הענף, היא, בדיקת החתך של הענף ע"י יודיד האשלגן (IKI) הענף המומת ע"י הפטריה אינו מכיל עמילן; במעבר מהחלק המת לחלק הבריא נעלם העמילן באופן הדרגתי והצביעה לא־רגולרית. בהמשך, החלקים הבריאים נצבעים באופן חזק, מה שמעיד על מציאות עמילן בשפע. לעתים רחוקות בודדה הפטריה מהמקומות הבריאים האלה, ומציאותה היתה מוגבלת ל־15 — 20 ס"מ מאחרי המקום שבדיקת העמילן מתחילה להיות חיובית.

ההתאמה בין מציאות הדיפלודיה ברקמות וההעלמות ההדרגתית של העמילן יכולה להודות, כי אזילת מלאי העמילן היא תוצאה של ניצול הפחמימות על ידי הפטריה.

בדיקת העמילן שמשה כמורה דרך בגיזום עצי שמוטי בהדברת הדיפלודיה.

שנוי בפרי אַפרסק ע"י טפרינה

מאת ג. מינץ

פירות אפרסק C. Smith נמצאו נגועים במעורר מחלת סלסול העלים, הנגרם ע"י פטריה Taphrina deformans, בפעם הראשונה בשנת 1945. בשנת 1949 היתה המחלה נפוצה בצורת מגפה בעלים של זני אפרסק רבים (נקטרינה נשארה בלתי־נגועה). באפרסק סמית נמצאו פירות נגועים, אשר עקב המחלה שינו את צורתם למאורכת, כמו שזה קורה בשזיפים הנוגעים ע"י T. pruni.

יצירה המונית של נבגים בפטריה DIPLODIA NATALENSIS ובפטריות אחרות הגורמות למחלות פרי הדר

מאת פ. ליטאור וי. גוטר

בחמשה המינים והזנים של זרעי תבואה שנבחנו בקשר עם כושרם לשמש קרקעות מזון ליצירה המונית של נבגי Diplodia natalensis הצטיינו זרעי שבולת שועל ביותר. הם נתנו המון נבגים חיוניים בעלי כוח הדבקה חזק לתקופת זמן של לפחות 12 חודש. האפול עקב את יצירת המכלאים (פיקנידיות) על הזרעים האלה.

12 פטריות אחרות הגורמות מחלות בפירות הדר נבחנו על זרעי ש׳ש, אולם גידול נתנו רק Phomopsis ו- Sphaeropsis.

מחזור המים של האלון התבורי

מאת ה. ה. אופנהימר

בדיקה קיצית של האלון התבורי בסביבת זכרון יעקב הוכיחה כי עצמת הטרנספירציה חזקה מאד והיא דומה לזו של עצי הדר מושקים. נראה כי האופי הפתוח של יערות האלון התבורי הטבעיים קשור בתצרוכת המים הגבוהה של מין זה העולה בהרבה, בחישוב על משקל העלים, על זו של האלון המצוי.

השפעת איזופרופיל קסנתוגנט הנתרן על תפו״ז שמוטי

מאת י. פלטי וצ. אבנר

ריסוס עצי תפו״ז שמוטי באיזופרופיל קסנטוגנט הנתרן, בתרכוזת של 1.5% (3.5 ק״ג לדונם) ולמעלה, גרם לנשירת רב העלים וכל הפירות לאחר ימים אחדים.

ניתן תאור התופעות שנתגלו בעלי השמוטי ובפירותיו אחרי הריסוס. השפעת הריסוס מוגבלת בהחלט לאותם העלים והפירות שרוססו במישרין.

הדברת רקבון החום של פרי הדר ע״י NCl_3

מאת פ. ליטואר ומינה נדל־שיפמן

נבדקה יעילות NCl_3 בהדברת הרקבון החום הנגרם ע״י Phytophthora citrophthora בפירות ת״ז שמוטי ואשכוליות.

הנסיונות שנעשו עם הדבקה מלאכותית של הפטריה הראו שגז NCl_3 מסוגל להדביר את הרקבון החום, אם הטפול נעשה לא יותר מאוחר מאשר 24 שעות אחרי ההדבקה. בנסיונות עם פרי מודבק ע״י פיטופטורה באופן טבעי בפרדס, הטפול בגז NCl_3 הנעשה לפי המקובל 48 שעות אחרי הקטיף, לא יהיה יעיל בהדברת הרקבון.

חתכים מיקרוסקופיים, בידודי החידק בתרבות טהורה, נסיונות הדבקה בלוית ביקורת, ובידודי התרבות מהפירות המודבקים (תלושים ומחוברים לצמח) הראו בעליל כי הנגע נגרם ע"י בקטריה נושאת ספורות שהוגדרה כ־Bacillus polymyxa (Prazmowski) Migula. האורגניסמוס צומח בנקל על אגר תפוח־אדמה בתוספת גלוקוז. הצמיחה האופטימלית בטמפרטורה של 37°C, המקסימלית 50°C והמינימלית 16°C—14. הנבגים אינם נובטים לאחר חמום במשך 10 עד 20 דקה ב־100°C.

נבדקה הפתוגניות של החידק לגבי עלי פלפל, פירות עגבניה תלושים ומחוברים לשיח, וכמו כן לגבי מספר ירקות אחרים בתנאי מעבדה. על עלי הפלפל המודבקים לא התפתח כל נגע. לעומת זאת על פירות העגבניה התלושים והמחוברים לשיח התפתח נגע ברור באם נשמרו התנאים הדרושים להתפתחות, היינו: לחות מספיקה וטמפרטורה של 37°C—30, וכמו כן טמפרטורה שגעה מ־20°C—18 במשך הלילה ל־37°C—30 במשך היום.

על כל פירות הפלפל והעגבניה המחוברים לצמח והתלושים גם יחד היתה התפשטות הנגע ועוצמתו מהירה וגדולה יותר בטמפרטורה של 37°C מאשר בטמפרטורה של 30°C, ובלחות יחסית גבוהה יותר מאשר בנמוכה יותר. אך נמצא כי פירות הפלפל עלולים להפגע יתר על נקלה בתנאי לחות יחסית נמוכה יותר, וטמפרטורה נמוכה יותר מאשר פירות העגבניה.

נוכחותם של תנאי לחות רוויה וטמפרטורה של 37°C—30 היו דרושים כדי לקבל תוצאות חיוביות לגבי מספר ירקות אחרים. גם כאן היתה התפשטות הנגע גדולה ומהירה יותר בטמפרטורה של 37°C מאשר בטמפרטורה של 30°C.

שיטות להערכת נגיעות ב„עין הטווס" בעצי הזית

מאת י. פלטי

ניתן תאור של שיטות להערכת מידת הנגיעות של עין הטווס (Cycloconium oleaginum) בעצי זית, בהתחשב עם התפשטות המחלה בעלים שעל העץ ועם נשירת העלים הנגרמה על ידיה.

אופי העבוד של הנתונים שנאספו לפי השיטות הנ"ל הותאמו למטרת ההערכה, ביחוד בקשר עם החשיבות היחסית של נשירת העלים. נעשו הצעות מפורטות לדרכי העבוד במקרה שההערכה מתכוונת לקביעת מידת ההתפשטות של הפטריה (חקירה פנולוגית) ובמקרה שמטרתה לקבע השפעת המחלה על פונדיקאיה (סקירות, נסיונות להדברה).

נסיונות להדברת מחלת עין־הטוס בזיתים

מאת י. פלטי, ש. מלר וי. ריכרט

שלשה נסיונות להדברת עין הטוס (Cycloconium oleaginum) בעלי הזיתים בוצעו מ־1943/44 עד 1945/46 במקוה ישראל ובגבת. רסוס במרק בוררו בתרכוזת של 1% ובפרנוקס בתרכוזת של ⅓% נתן תוצאות משביעות רצון.

בתנאים נוחים להתפתחות הפטריה, המביאים לידי התפרצות קשה של המחלה, אין להדבירה ברסוס אחד בלבד, אולם שני רסוסים, אחד בקיץ והשני בסתיו או בתחילת החורף נתנו תוצאות טובות. לרסוס נוסף באביב לא היתה השפעה ניכרת.

בתנאים של נגיעות בינונית־קלה, הצליח רסוס יחידי בקיץ להדביר את המחלה במדה רבה.

תורת ליסנקו מבחינת תורת חוגי־החיים בפטריות

מאת ריכרד פלק

תורת מיטשורין־ליסנקו שהגנים המעבירים גורמי תורשה נתונים להשפעת הסביבה נידונה לאור המחקר שנעשה ע"י המחבר במשך 40 שנה.

הפטריות במשך התפתחותן הפיליגנטית סיגלו את המנבגים (ספורנגיות) שלהם לשם הבטחת התפשטות נבגים יעילה לתנאי מים — מנבג המים או ה'דרוספורנגיה של קבוצות הפטריות הנקראות Archimycetes, Chytridiales ו־Oomycetes או לתנאי אוויר — מנבג האדמה או גיאוספורנגיה של קבוצת ה־Zygomycetes או למעבירים אחרים, כגון חיות בקבוצת ה־Vescocarpi omycetes.

שנויים ידועים בתפטירים של פטריות אחדות התהוו באותו הזמן ובאופן מקביל לשנויי ההסתגלות במנבגים שלהן.

כדי לבאר את אלה התצפיות ועוד אחרות המחבר מניח הנחת היפותזה שלכל טיפוס גוף הומולוגי ולכל גורם תורשה (גן) יש תכונות כפולות של יציבות יחסית ושל השתנות יחסית. ההשתנות נותנת את הכשר לקבל או לאבד סגולות אופייניות, והיציבות מקנה את התנאי הראשי הטבעי בשביל הורשה. המסקנות האלו מתאימות בעיקרן לתורת מיטשורין־ליסנקו בנוגע לגן המשתנה.

חלדון באורן ירושלים

מאת י. ריכרט ומתילדה חורין

בשנת 1946 נתגלתה מחלת החלדון על מחטי אורן ירושלמי. צורת החלדון באורן הוגדרה כ Peridermium. צורת ה־Coleosporium נמצאה בארץ על צמחי Senecio ו־Inula.

ניתן תאור מפורט של שתי צורות החלדון בארץ ונידונה העמדה הסיסטמתית של שתיהן. טיב הפרידרמיום לא הוכרע. כלפי זה הוחלט שממצאי הקולאיוספוריום שייכים למינים: C. senecionis ו־C. inulae.

העובדה ששתי הצורות נמצאו בשטחים הרחוקים אחד מן השני בטיבם האקלימי, מעידה שאין צורך ששתיהן תמצאנה בקרבת מקום, ובאקלים דומה, כפי שחשבו עד כה.

מחלת החלדון של האורן יכולה להחשב כמסוכנת רק בשנים גשומות ויוצאות מן הכלל. יש לקחת בחשבון שעצי אורן נטועים על מורד עם מפנה מערבי, ומערבי־צפוני נוחים יותר לקליטת המחלה ומשום כך יש להמנע, עד כמה שאפשר מלנטע עליהם אורן ירושלמי.

מחלת כתמים על פירות פלפל הנגרמת ע"י *BACILLUS POLYMYXA*

מאת צפרירה אלעזרי—וולקני

מחלת כתמים על פירות פלפל מתוק אשר לא נזכרה עד כה בספרות הופיעה בדרום ובמרכז הארץ בחדשי אוגוסט־ספטמבר שנת 1947, ונגרמה ע"י בקטריה נושאת ספורות. הנגע הופיע בצורת כתמים חומים אפרפרים בהירים, יבשים או רכים, שקועים במקצת, בקוטר של 8 עד 12 מ"מ. לפרקים בלטו העורקים בתוך הכתמים, והוו מעין רשת חומה כהה על רקע בהיר יותר. מספר הכתמים על כל פרי נע בין 1 או 2 עד ל־5.

השפעת תנאי-אקלים שונים על תכונות מסוימות של תפוחי-עץ

מאת י. דמסט הי"ד

המחבר בדק תפוחים שגדלו בישראל או בעמק או בהר וקבע את ההבדלים כדלקמן:

פרי־הרים ארוך יותר בצורתו ולעתים קרובות בעל צלעות. השטח האדום אשר לעורו גדול יותר בהשוואה עם פרי מהעמק.

ההיפודרמיס — אך לא הקוטיקולה — בפרי ההרים עבה יותר. יש בו גם יותר חומר יבש, סוכר, תאית, חומצה ואפר, אך פחות חלבונים.

עוצמת הנשימה נמוכה ביחס בפרי ההרים ונמצא שהיא תלויה בשעור החלבונים.

נדמה שההבדלים הנ"ל נגרמים בשורה הראשונה ע"י עוצמת האור, הרכבו לפי אורך גליו וע"י מידת החום.

יוצא כי פרי־הרים בעל איכות משובחת יותר הודות למראהו הנאה, טעמו הטוב ויכולתו להשמר זמן רב יותר באחסנה.

השפעתם של חמרי צמיחה סינתטיים על השרשת יחורי גפן

מאת ל. הירימן—הרשברג

נבדקה השפעתם של חומצה אורתו־כלורו־פנאוקסי אצטית וחומצה beta-נפתאוקסי אצטית על ההשרשה ואיחוי ההרכבה של יחורי גפן. שני חמרי צמיחה סינתטיים אלה, בריכוזיהם המתאימים, שיפרו את השתרשות היחורים של כנות הגפן: Rupestris du Lot, Chasselas-Berlandieri 41B, Solonis-Rupestris 216—3. הם גרמו להשתרשות מוקדמת יותר, למערכת שרשים מפותחת ולאחוז השרשה גדול יותר בהשוואה ליחורי הבקרת. כששמו את חמרי הצמיחה במקום אחוי ההרכבה נוצר קלוס חזק והוחש האחוי. הטיפול בחמרי הצמיחה עשוי, איפוא, לשחרר את השתלן מחימום היחורים המקובל לפני שתילתם.

אותם היחורים שהצמיחו מערכת שרשים טובה הצטיינו גם בגידולם החזק במשתלה.

בהשואה של לנולין וטלק כנושאים של החמרים הפעילים נראה השימוש בטלק נוח יותר. ברם תוצאותיו פחות בטוחות מבלנולין.

טבילת יחורי הגפן לתוך אמבטיות חמות של מים או של תמיסות מהולות של חמרי הצמיחה שיפרה את השתרשות היחורים במקרים מסוימים.

נעשו הסתכלויות אנטומיות על יצירת השרשים ביחורים.

בדיקה של שני חומרי צמיחה סינתטיים בעזרת גלילים מנדן הפסיג של שבלת השועל

מאת ל. הירימן—הרשברג

חומצה אורטו־כלורו־פנאוקסי־אצטית וחומצה β -נפתוקסי־אצטית נבדקו בעזרת גלילי קוליאופטילה של שבלת שועל לפי שיטתו של Thimann המתוקנת ע"י Jost & Reiss. שני חומרי הצמחיה הנ"ל נמצאו פעילים בבדיקה זו. הרכוזים האופטימליים היו לגבי החומצה הנפתוקסי־אצטית בין 1 ו 10 מ"ג לליטר, ולגבי החומצה הכלורו־פנוקסי־אצטית בין 10 ו־100 מ"ג לליטר.

מתכונת דו־תחמוצת הפחמן באויר, בפרדס

מאת ש. פ. מונסליזה

מתכונת דו־תחמוצת הפחמן נקבעה בפרדס ליד עץ אשכולית מבוגר בשעות שונות של היום, ובעונות שונות של השנה. לא נמצאו הבדלים חוזרים לפי המקום ממנו שואבים את האויר (מהיקף העץ או מתוך נופו) ולפי כך אם שואבים אותו באיזו שהיא עונה בבוקר או בשעות אחרי הצהרים. בלילה היתה המתכונת ב־20% יותר גבוהה מזו שנקבעה באותה טמפרטורה, בשעות היום. כשהתוצאות בוטאו באחוזי המשקל של האויר, נראתה השפעה בולטת של הטמפרטורה על מתכונת הגז הנ"ל. בה במדה שטמפרטורת האויר עלתה מ־15^0 לפי צלסיוס עד 28^0, ירדה מתכונת הגז באויר, מ־0.0396% עד 0.0357%. מעל ל־28^0 חל מפנה פתאומי בתלות מתכנת ה־CO_2 בטפמפרטורה והמתכונת במקום לרדת גדלה במהירות עם כל עליה נוספת של הטמפרטורה (ראה את התמונה בעמוד 83). המינימום של מתכונת דו־תחמוצת הפחמן באויר מתקבל, לפי הנראה, בטמפרטורה המאפשרת הטמעת פחמן ע"י הצמחים, והירידה בטמפרטורות גבוהות יותר הנה תוצאה של נשימתם המנוגדת לתהליך הטמעת הפחמן.

שעור המנגן בעלי השמוטי

מאת עמיחי כהן

נראו בעלים תופעות בהקת שצורתן עוררה חשש כאילו הנן פרי תוצאה מחוסר מנגן. נעשו, איפוא, אנליזות עלים לבחינת שעור המנגן אשר בחומר היבש של העלים. נבחנו עצים מקרקעות שבהם עולה ה־pH על 7.5, ז. א. על הסף הנחשב כגבול עליון למסיסות ול„זמינות" המנגן לצמח. אולם קליטת המנגן נמצאה מספקת אף בקרקע שבו ה־pH עולה ל־8.5.

נראה דרוג ברמת המנגן בעלים בהתאם לטיפוס הקרקע, ה־pH שלו; וכמות המנגן הכולל שבו. בעצים שגדלו בחמרה נמצאו 32.8 חלקי מיליון מנגן; בחול חמרה, 30.2; בחול עמוק, 25.6 ואילו בכורכר, 16.0. מינימום מתכונת המנגן בו רואים סימן מובהק למחסור ביסוד זה הוא למטה מ־10 חלקי מיליון ממשקל העלים היבשים. עלים מעצים נגועי בהקת הכילו שעור גבוה יותר של מנגן ויש לשער כי כמות זו נקלטה נוכח מחסור באבץ שהוא כנראה הגורם האמיתי לבהקת הנדונה.

השפעת רסוס בשמן על נביטת זרעי הדר והתפתחות השתילים

מאת יעקב פת

שמן להדברת עשבים רוסס על אדמת חול וחמרה. השמן ניתן בשתי כמויות: גדושה ובינונית, ברסוס אחד. כמות מתאימה מהקרקע לשכבותיה השונות העברה לעציצים, בהם נזרעו זרעי חושחש. ואלו תוצאות הנסיון:

א. — חל עכוב בנביטת הזרעים בהתאם לכמות השמן שרוססה, אולם הם הגיעו לבסוף לנביטה אחידה. עשבי בר מסוימים לא נבטו כלל או שחלה נביטה חלקית בלבד, במשך חודש וחצי.

ב. — בהתחלת הנסיון, צבע העלים היה צהבהב אך הפך, אח"כ, נורמלי.

ג. — גדול הנבטים לגובה נעכב תחילה, בעיקר באדמת החמרה, בהתאם לכמות השמן.

ד. — לא נראו נזקים במערכת השרשים.

ה. — אין לחכות לנזקים מרסוסים בחומרים מסוג זה בעצי הדר מבוגרים בתנאי שלא ישתמשו בבת אחת בכמויות גדושות.

מחקר על הפנולוגיה של זני חטה אחדים בא"י

מאת ד. זיו

נבחן משך הזמן מן הנביטה עד ההשתבלות של חמשה זני חטה שנזרעו 7 פעמים החל מה־9 באוקטובר ועד ה־3 באפריל.

א. הזן הבכיר ב. י. פ. מ. השתבל לפי סדר הזריעה כעבור 28, 33, 41, 63, 54, 45, 38 יום, ואילו הזן האפיל נורסי כעבור 184, 166, 131, 106, 82, 62, 60 יום. יתר הזנים הבכירים השתבלו בדומה לב. י. פ. מ. והאפילים בדומה לנורסי.

ב. משך הזמן מן הנביטה עד להופעת קודקוד הצמיחה הרפרודוקטיבי בקנה הראשון היה קטן יותר בזנים הבכירים והקביל לעליה ולירידה במשך הזמן מן הנביטה עד ההשתבלות הנ"ל בזן ב. י. פ. מ. בזנים אפילים הוא הקביל לירידה המתמדת של הנורסי.

ג. לאחר שהשתבלו הצמיחו הזנים הבכירים קנים נוספים שהשתבלו אף הם, וכך הגיעו ל־3—4 סדרות של השתבלות. הם חזרו בזאת לאחר „דרגת התפתחותם הסופית" (לפי ליסנקו), ז. א. של הפריחה, לדרגה קודמת „וגטטיבית", והיו דומים בזאת לצמח פוליקרפי.

ד. מבחינה פוטופריודית הזנים הבכירים לא התנהגו כצמחי היום הארוך.

ה. מספר העלים הסופי בכל קנה היה קטן יותר ככל שהזן היה בכיר יותר.

נביטת זרעי הדר בקשר עם אי אלו שיטות הנהוגות בשתלנות

מאת ד. ל. אלזה

נחקרו כמה בעיות הכרוכות בנביטת זרעי כנות לעצי הדר כגון: לימטה מתוקה, לימון גס, חושחש והדר תלתני (*Poncirus trifoliata*).

אחרי שהגרעינים נשארו זמן מה במיץ הפירות או בתערובת של מיץ ומים, היתה הנביטה בדרך כלל נמוכה מהרגיל. נחוץ, איפוא, לנקות ולחטא את הגרעינים מיד אחרי הוצאתם מהפירות, ואין זה נכון להשאירם בתוך פירות רקובים כנהוג ע"י רבים. גם שמירת הזרעים בפרי קטוף, שאינו רקוב, עלולה להאיט את הנביטה. סטרטיפיקציה של זרעי ההדר התלתני הגדילה וזירזה בהרבה את הנביטה. ביתר הזנים השפיעה הסטרטיפיקציה פחות, אם כי הנביטה היתה מהירה ואחידה. שמירת זרעים רטובים בחול או באבקת פחם בקופסאות סגורות נתנה אותן התוצאות כמו הסטרטיפיקציה. בין גרעיני הלימטה המתוקה ישנם כאלה הצפים על פני המים. נביטתם גרועה מזאת של הזרעים הטובעים, אך מספרם קטן מדי כדי שיהיה כדאי להפריד בין אלה ואלה. נמצא כי העומק של 3—2 ס"מ הוא המתאים ביותר לזריעה.

על צמחית הקלימקס של הנגב

מאת ה. בויקו

שליטתם הנוכחית של הצמחים הנפוצים ביותר כיום בחלקים הדרומיים של הארץ (הנגב ועמק הערבה) — הנה תוצאה של רעיה מופרזת במשך מאות שנים. כך התפתחו באזורים הפחות שחונים חברות לענת המדבר (*Artemisia Herba alba*) ובאזורים היותר שחוניט חברות יפרוק המדבר (*Anabasis articulata*) לדרגותיהן הנוכחיות.

מבוססות על הנחות אלה ועל תרשימים פיטוסוציולוגיים, שאחדים מהם מובאים כאן לדוגמה — נעשה ניסון לתאר בקוים כלליים את צמחית הקלימקס של האיזורים הנידונים. הצמחיה מחולקת להברות קלימקס הבאות:

1) ערבה של דגניים גבוהים: חברת מלענן — מלעניאל (*Stipa—Aristida*), באיזורים בעלי 200 מ"מ משקעים בערך, או יותר.

2) ערבת דגניים נמוכים: חברת המלענן הקהה (*Aristida obtusa*), באיזור בעל 200—150 מ"מ של משקעים.

3) את צומח הקלימקס של האיזור הגובל עם המדבר האמיתי, בעל פחות מ־150 מ"מ משקעים שנתיים, יש לחלק לשלשה איזורי סוב־קלימקס, בהתאם להשפעת גורמים אדפיים אשר נהיים כאן לקובעים.

חברות סובקלימקס אלה הנם:

א. חברת השבטוט — הפרקרק הפרסי (*Calligonum—Haloxylon persicum*) על החול.

ב. חברת סילון — זוגן שיחני (*Zilla spinosa – Zygophyllum dumosum*) על מדרונות ושטחי חמדה.

ג. חברת השיטה הסלילונית (*Acacia Raddiana*), באפיקי חצץ שטוחים של נחלי אכזב.

4) צמחית המדבר האמיתי בדרום מאופינת ע"י השיח *Haloxylon salicornicum*. אין המאמר מטפל בנאות מדבר באשר בעית צמחית הקלימקס שלהן מסובכת היא.

התנאים האיקולוגיים של הפרקרק הפרסי (*Haloxylon persicum*) מתוארים ביתר פרוטרוט ומדובר על גלוי שלושה עצים זקנים בני כאלפים שנה. רצופה מפת התפוצה הגיאוגרפית של הפרקרק הפרסי שמראה אמפליטודה רחבה באופן מפתיע לגבי הטמפטרטורה.

כמו כן, נעשה נסיון למצא דירוג ביאולוגי למדת השחינות ע"י אינדיקטורים צמחיים (ראה תרשים). כמו־כן נידונו בעיות מרעה מנקודות ראות שונות ובעיות שקום של איזורים חצי־מדבריים בכלל.

קביעת רוחב הפתיחה של הפיוניות בעלי העגבניה

מאת ה. ר. אופנהיימר

נמצא כי ע"י טבילת העור העליון של עלי העגבניה לתוך דיוכסאן, מיד אחרי הסרתו מהעלה, נשמרות הפיוניות במצב פתיחתן הטבעי, אך בכהל דרגת הפתיחה יורדת באופן ניכר. כשרטיבות האויר ירדה עד למטה מ־30%, הפיוניות נשארו סגורות.

מיני החבור הסימביוטי ומשמעותם בהתהוות צורות וחוגי החיים בתהליך ההתפתחות הפילוגנטית.

מאת ריכרד פלק

המחבר מבדיל בין שני מיני שותפות חיים (סימביוזיס), אחת הנקראת שותפות חיים של פנים התא (ציטוסימביוזיס) המתהווה ע"י התחברות של הכרומוזומים או הגרעינים בתוך התא, והשנית נקראת שותפות חיים של גופים (סומטו־סימביוזיס) והיא מתהווה ע"י חיבור של חלקים שונים באותו הגוף או בגופים שונים.

ביחוד נידון היחס בין הפטריות הנקראות הטפיליות ובין האכסנאים השונים שלהם. המחבר בא לידי מסקנה שהיחס הזה אינו תמיד יחס של נזק בלבד אלא יש והוא מביא תועלת לשני השותפים. ההנחה הזו נתמכת גם ע"י עובדות שנקבעו במחקר המיקוריצה ובשטח הפתולוגיה של חיות.

גורמי־אקלים קיצוניים הקובעים את תפוצת הצמחים

מאת ה. בויקו

1. באיזורים אריידיים שטחי התפוצה של צמחים חד־שנתיים נתונים לתנודות גדולות בתלות ישירה מן המשקעים.
   דבר זה מוחש ע"י דוגמאות ממדבר יהודה ומהנגב. מובאות טבלאות פיטוסוציולוגיות עם נתונים על מספר הצמחים וגודלם, במרובעים.
2. כמו־כן נדונה השפעת תופעות מטאורולוגיות קיצוניות על תפוצת צמחים רב־שנתיים וצמחים מעוצים.
3. מראים, כי גם את התנודות בשטחי התפוצה של צמחים מעוצים אפשר לחקור ע"י שיטות חקירה פשוטות.
   גורמים מקומיים, אשר אין להם חשיבות בתנאים פחות קיצוניים, נהיים קובעים בשביל היעור והטפול במרעה באיזורים אלה הקרובים לגבול בו נעלמים הצמחים. דבר זה מוצג ע"י כמה דוגמאות טפוסיות, כמו זו של השברק הקוצני Ononis leiosperma בסביבת ירושלים.
4. לא רק עוצמת הגורמים האקלימיים הקיצוניים, אלא גם תדירות הופעתם הנה חשובה להסבר תנודות התפוצה הנידנות. לשם קביעת השפעתם מגדירים את המקדם I-F המשקף עוצמה ותדירות הגורם גם יחד.

השפעת הכפור על הצומח בחורף תש"ט

מאת ה. ר. אופנהיימר

בחורף תש"ט ירדה הטמפרטורה בכמה לילות לדרגה נמוכה היוצאת מגדר הרגיל ונזק קשה נגרם לעצי פרי טרופיים כעצי הדר ומנגו, בננות, וצמחי נוי רבים שמוצאם בארצות טרופיות כגון בוגנוויליה, לנטנה, בודליאה ומיני פיקוס שונים. צמחית הבר המקומית כמעט שלא נפגעה: עשבי־בר רבים נקפאו, אך לא סבלו מזה כל נזק, לעומתם הסרפד הצורב, הירבוז המפשל, ענבי שועל, כף האוז הריחני וכו' סבלו בהיותם מותאמים לטמפרטורות גבוהות ביחס. בעצי הדר חומרת הנזק נקבעה ע"י מין הרוכב והכנה, המצב הטופוגרפי של השטח וטיב הטיפול.

עתון לבוטניקה

פרופ. י. אלעזרי-וולקני — בן 70.

ארץ ישראל החקלאית חגגה לפני זמן מה את חג יובל השבעים של פרופ. י. אלעזרי-וולקני, מנהל התחנה לחקר החקלאות ועד הזמן האחרון ראשו של המכון ללמודי החקלאות של האוניברסיטה העברית, ירושלים.

פרופ. וולקני בא לפני 42 שנה לארץ, וידוע אז כאגרונום יצחק ווילקנסקי מבית מדרשם של מוריו הפרופסרים סרינג' מיטשבליך ושטוצר. הוא נתקל אז במשבר בהתישבות העברית. העקרונות החדשים שיצחק ווילקינסקי — ידוע בשמו הספרותי א. ציוני — הכריז היו: 1) ההתישבות צריכה להתבסס על עבודה עצמית, 2) המשקים החדשים צריכים לשאוף לאספקה עצמית. אולם כחניך המדע, הוא הכיר כבר אז שבלי נסיונות חקלאיים מפורטים ובלי מחקר מדעי יסודי לא נוכל להתקדם, והוא נגש לבצוע רעיונותיו. בשנת 1909 יסד את חות בן שמן שבה קבל את התוצאות החשובות הראשונות בהגדלת תנובת הלול והרפת. בשנת 1921 יסד את התחנה לחקר החקלאות שהמשיכה תחת הנהלתו למצוא דרכים להרמת יבולי שדות הדגן והמקשה, והכרמים והפרדסים ע"י אופני זבול, עבוד, השקאה, הדברת מחלות ומזיקים והנחת יסודות בריאים לתכנון המשק; תוצאות עבודה ממושכת שפורסמו ביותר מ־300 מחקרים. פרופ' וולקני פרסם בעצמו המון מאמרים שהדריכו את החקלאות והובילו לתכנון יעיל של ההתישבות. הם קובצו יחד בספריו „בדרך" ו„מידות" המשמשים עוד היום קו ומשקולת בהתהוות התכניות של ההתישבות החדשה אחרי יסוד המדינה. הוא גם פרסם מחקרים מונוגרפיים בעברית ובאנגלית על „משק הפלחה" „המעבר ממשק פרימיטיבי לאינטסיבי", „משק הקבוצים", „על המשק המוערב", על „משק החלב" ועוד. עבודותיו עוררו הערצת מלומדים ואנשי מעשה חקלאיים בעולם, כגון פרופ. אלווד מיד הידוע באמריקה ואחרים. פרופ. וולקני הוזמן בסוף המלחמה להרצות בקהיר על משקי החקלאות העברית. ב־1949 הרצה בכנוס המדעי של מכון ווייצמן על אפשרות הפתוח של ארצות המזרח התיכון הנחשלות. לרעיונותיו לקידום החקלאות יש חשיבות לא רק לארץ ישראל אלא לכל הארצות השחונות שהוזנוחו במשך הדורות ע"י הטבע ותושביהן.

ה מ ע ר כ ת

כרך שביעי זה של העתון לבוטניקה, סדרת
רחובות, מוקדש למנהל התחנה לחקר החקלאות
הפרופיסור **יצחק אלעזרי-וולקני**
חלוץ ההתישבות המתוכנת העברית בישראל
בהגיעו לשיבה.

עתון לבוטניקה

מופיע בשתי סדרות

א. סדרת רחובות:

יוצאת לאור ע"י ה. ר. אופנהיימר וי. ריכרט מהתחנה לחקר החקלאות, רחובות, ישראל. לפי תכניתנו כל כרך בסדרה זו יכיל 2 חוברות (200—300 עמודים) שתופענה משך שנה ככל האפשר.

ב. סדרת ירושלים:

יוצאת לאור ע"י חבר העובדים של המחלקה לבוטניקה באוניברסיטה העברית בירושלים. לפי התכנית כל כרך בסדרה זו יכיל 4 חוברות (300—400 עמודים) שתופענה משך שנה ככל האפשר.

את דמי החתימה יש לשלם למפרע ע"י שק או המחאת דואר. מחיר החתימה הוא:

1.250 ל"י לכרך, בעד סדרת ירושלים

0.900 ל"י לכרך בעד סדרת רחובות

בסכומים אלו אינם נכללים דמי המשלוח.

את דמי החתימה ואת המכתבים הנוגעים בעניני המערכת יש לשלח לפי הכתובות הבאות:

לסדרת ירושלים: עתון לבוטניקה, ת.ד. 620, ירושלים.

לסדרת רחובות: עתון לבוטניקה, ת.ד. 15, רחובות.

במכתבים הנוגעים בשתי הסדרות אפשר לפנות לכל אחת מהכתובות הנ"ל.

את רוב הכרכים הקודמים של סדרת רחובות אפשר להשיג במחיר של 0.900 ל"י כ"א.

דפוס מ. שהם, תל-אביב, רח' פין 6, טל. 2239

סדרת רחבות כרך ז', חוב' א'-ב' כסלו תש"י

עתון לבוטניקה

סדרת רחבות

(לפנים רשימות לבוטניקה ומדעי גננות)

יוצא לאור על ידי
ה. ר. אופנהיימר וי. ריכרט
מהתחנה לחקר החקלאות, רחבות, ישראל

מזכיר המערכת:
י. פלטי

רחבות, ישראל